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# Farmer Adoption of Best Management Practices Using Incentivized Conservation Programs

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FARMER ADOPTION OF BEST MANAGEMENT PRACTICES  
USING INCENTIVIZED CONSERVATION PROGRAMS

A Thesis Presented

by

Jennifer Miller

to

The Faculty of the Graduate College

of

The University of Vermont

In Partial Fulfillment of the Requirements  
for the Degree of Master of Science  
Specializing in Community Development & Applied Economics

October, 2014

Accepted by the Faculty of the Graduate College, The University of Vermont, in partial fulfillment of the requirements for the degree of Master of Science, specializing in Community Development & Applied Economics.

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## **ABSTRACT**

Many farms in the United States impose negative externalities on society. Population growth and the accompanying increase in demand for food further promote this trend of environmental degradation as a by-product of food production. The USDA's Environmental Quality Incentives Program (EQIP) provides financial assistance to farmers who wish to address natural resource concerns by making structural improvements or implementing best management practices (BMPs) on their farms. Regional examinations of program implementation and incentive levels are needed to evaluate the effectiveness of EQIP at both the farm and environmental level. This research addresses this need in the following two ways. First, conjoint analysis was used to calculate the willingness to accept incentive levels desired by Vermont farmers for implementing three common BMPs and the relative importance of each attribute in their adoption decisions. Next, a survey was conducted to document Vermont farmers' experiences, or choices not to engage, with EQIP. The results of the conjoint analysis indicated that farmers' adoption decisions are most heavily influenced by the available implementation incentives and that the higher the incentive level offered, the more willing farmers are to adopt a practice. The survey results triangulated these findings as cost was the most frequently cited challenge farmers face when implementing BMPs and one third of respondents felt the cost-share amount they had received was inadequate. Although 46% of respondents reported receiving nonmonetary benefits, 43% had encountered challenges when enrolling or participating in EQIP. In addition, though contracts are designed to address specific resource concerns, 30% of respondents had not fully fixed the original issues with their contracts. This also indicates that the incentive levels offered in EQIP contracts may be lower than Vermont farmers' preferred incentive levels, affecting the adoption rate of BMPs and subsequently the environmental health and long term sustainability of Vermont's agricultural systems. Program areas ripe for improvement, key points for farmers weighing the costs and benefits of program participation, and future research opportunities are discussed in order to guide efforts to improve the effectiveness of EQIP in Vermont. This research also raises awareness of how much it costs to simultaneously support environmental health and food production in our current food system and who ultimately should bear this financial burden.

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## TABLE OF CONTENTS

ACKNOWLEDGEMENTS .....	ii
TABLE OF CONTENTS.....	iii
LIST OF TABLES .....	ix
LIST OF FIGURES .....	x
CHAPTER 1: INTRODUCTION .....	1
1.1 Background .....	1
1.2 Article 1 Research Questions.....	2
1.3 Article 2 Research Questions.....	3
CHAPTER 2: LITERATURE REVIEW .....	4
2.1 Environmental Impacts of Agricultural Systems .....	4
2.1.1 Water & Agriculture .....	4
2.1.2 Soil & Agriculture .....	5
2.1.3 Climate Change & Agriculture.....	6
2.1.4 Brief Overview of Vermont Agriculture .....	7
2.2 Resiliency in Agricultural Systems.....	7

2.3 Best Management Practices .....	9
2.4 Farmer Adoption of Best Management Practices .....	10
2.5 Economic influences on decision-making .....	13
2.6 Incentives for BMP Implementation.....	15
2.7 Environmental Quality Incentives Program.....	17
2.7.1 EQIP: Funding .....	19
2.7.2 EQIP: Contract Approval Process .....	20
2.7.3 EQIP: Cost-share Payments.....	21
2.7.4 EQIP: Voluntary Approach to Conservation .....	23
2.7.5 EQIP: Contract Outcomes .....	24
2.7.5 EQIP: Research Needs.....	26
2.8 Cover Crops .....	27
2.9 Conservation Tillage.....	32
2.10 Conservation Buffers .....	35
2.11 Conservation practice implementation in Vermont .....	40
2.12 Research Needs .....	41
CHAPTER 3: CONJOINT ANALYSIS OVERVIEW.....	43

3.1 Stated Preference Approaches .....	43
3.2 Designing a Choice Model.....	44
3.3 Validity and Reliability Issues .....	49
CHAPTER 4: METHODS .....	51
4.1 Article 1 Methods .....	51
4.1.1 Data Collection .....	51
4.1.2 Demographic Analysis .....	53
4.1.3 Conjoint Analysis .....	53
4.1.4 Question Design.....	54
4.1.5 Conjoint Question Response.....	55
4.1.6 Preference Model and Variable Coding .....	56
4.1.7 Weighting of Observations .....	57
4.1.8 Weighted Least Squares Regression.....	59
4.1.9 Part-worth Utilities .....	60
4.1.10 Relative Importance.....	60
4.1.11 Estimation of Willingness-to-Accept .....	61
4.1.12 Additional Data Analysis.....	62
4.2 Article 2 Methods .....	64



4.2.1 Data Collection .....	64
4.2.2 Demographic Analysis .....	65
4.3 NRCS Data.....	65
CHAPTER 5: ARTICLE 1 .....	66
5.1 Introduction.....	66
5.1.1. Background.....	66
5.1.2 Incentivizing BMP Adoption.....	67
5.2 Methods.....	69
5.2.1 Data Collection .....	69
5.2.2 Demographic Analysis .....	71
5.2.3 Conjoint Question Design.....	71
5.2.4 Conjoint Analysis .....	73
5.3 Results.....	75
5.3.1 Summary Statistics .....	75
5.3.2 Conjoint Analysis .....	80
5.4 Discussion .....	87
5.4.1 Data Collection Process.....	87
5.4.2 Use of Conjoint Analysis.....	88

5.4.3 Demographic Analysis .....	91
5.4.4 Conjoint Analysis: Big Picture Conclusions .....	92
5.4.5 BMP Preferences & Part-worth Utilities .....	92
5.4.6 Relative Importance of Attributes .....	94
5.4.7 WTA Incentive Levels.....	94
5.4.8 Program Implications.....	96
5.4.9 Next Steps.....	97
5.4.10 Conclusion .....	99
CHAPTER 6: ARTICLE 2 .....	100
6.1 Introduction.....	100
6.1.1 Background.....	100
6.1.2 Literature Review .....	102
6.2 Methods.....	107
6.3 Results.....	108
6.4 Discussion .....	124
6.4.1 Cost-Share Amounts.....	124
6.4.2 Application Ranking & Contract Approval.....	125
6.4.3 Resource Concerns & Sustainability .....	126

6.4.4 Structural Improvements vs. Management Practices.....	127
6.4.5 Understanding Program Structure .....	128
6.4.6 Summary of Program Areas to Target.....	129
6.4.7 Farmers “Need to Know” EQIP List .....	129
6.4.8 Next Steps.....	130
6.4.9 Conclusion .....	131
WORKS CITED .....	132

## LIST OF TABLES

Table 1: Combinations of conservation practices offered in conjoint question.....	55
Table 2: Attribute names, levels, and variable types .....	57
Table 3: Frequencies of Weights .....	59
Table 4: Demographic Characteristics of Conjoint Respondents by Survey Group .....	76
Table 5: Demographic Characteristics of Conjoint Respondents (n=85) .....	78
Table 6: Respondents' Use of Conservation Practices & EQIP (n=85) .....	78
Table 7: Comparison of Survey Respondents with Vermont Farmer Population .....	80
Table 8: WLS Regression Results .....	82
Table 9: Attribute Part-Worths .....	83
Table 10: WTA of Farmers for Implementation of Conservation Practices.....	85
Table 11: Comparison of Mean Cost/Acre for 3 BMPs .....	86
Table 12: Demographic Characteristics of Respondents (n=61) .....	109
Table 13: Comparison of Survey Respondents with Vermont Farmer Population .....	111
Table 14: Respondent opinions about conservation practices and programs .....	113
Table 15: EQIP Participation Statistics by Main Product.....	115
Table 16: Summary of Respondents' Experiences with EQIP Contracts.....	117
Table 17: Frequency of Non-monetary Benefits & Challenges Received by Respondents .....	119
Table 18: Frequency of Reasons Respondents had Never Applied to EQIP .....	121
Table 19: Historical EQIP Incentive Payments .....	122

## LIST OF FIGURES

Figure 1: Most and Least Preferred Conjoint Options.....	81
Figure 2: Relative Importance of Attributes in Farmer Decision-Making .....	84
Figure 3: Frequencies of Structural Improvements in Respondents' EQIP Contracts ...	115
Figure 4: Frequencies of Management Practices in Respondents' EQIP Contracts .....	116

## **CHAPTER 1: INTRODUCTION**

### **1.1 Background**

The environmental degradation and negative externalities imposed on society by US agricultural production systems have been steadily increasing since the end of World War II (UNCTAD, 2013). These impacts include soil erosion, pollution of waterways and groundwater, greenhouse gas emissions, loss of biodiversity, shrinking wildlife habitat, and pesticide and fertilizer run-off and leaching (Grossman, 2011). Current trends in population growth and demand for food continue to fuel the production, and exacerbate the impact, of these externalities (UNCTAD, 2013). Climate change and variability will further compound the effects of these challenges to the long-term sustainability of agricultural systems (Walthall, Hatfield, Backlund, Lengnick, & Marshall, 2013). The need to ensure the resiliency and viability of our farms and food systems is a pressing and increasingly salient issue.

To incentivize farmers to supply more positive environmental externalities and encourage adherence to environmental regulations, in 1996 the USDA established the Environmental Quality Incentives Program (EQIP). This working lands conservation program provides financial assistance to farmers who wish to address natural resource concerns on their farms by making structural improvements or implementing best management practices (BMPs). The incentives provided include technical assistance and cost-shares of up to 75% of implementation costs. Given that farmers are navigating the cost-price squeeze and are at times unable to prioritize long-term investments that require large upfront investments, EQIP has the potential to play an important role in

simultaneously supporting the economic and environmental sustainability of US farms (Natural Resources Conservation Service, 2012).

In order for EQIP to prove effective at the farm-level, the program must deliver regionally appropriate programs, specifically with regard to incentive levels and technical services (Johansson & Cattaneo, 2006; Winsten et al., 2011). Farmers' willingness-to-accept incentive levels vary with their demographic and geographic characteristics (Claassen, Cattaneo, & Johansson, 2008; Johansson & Cattaneo, 2006). It follows that determining incentive levels that are cost-effective for both farmers and the federal government is challenging, though studies have shown that setting appropriate incentive levels is a key step in designing effective conservation programs and one that needs a continued regional research focus (Claassen et al., 2008; Cooper & Signorello, 2008; Wossink & Swinton, 2007). An examination of incentive levels does not provide a complete picture of on-farm program effectiveness yet few studies have focused on the functioning of other key program areas at the regional level. This project aims to provide that regional focus, first by calculating Vermont farmers WTA for three common best management practices and then by documenting Vermont farmers' perspectives on the realized effectiveness of EQIP. The research questions for this study are listed below.

## **1.2 Article 1 Research Questions**

- 1) What is Vermont farmers' willingness to accept (WTA) for each conservation practice?
- 2) What is the relative importance of each attribute on farmer adoption decisions?

3) How may the WTA results inform the implementation of cost-share programs in Vermont?

### **1.3 Article 2 Research Questions**

1) How does EQIP support the resiliency and viability of all types of farms in Vermont?

2) Do Vermont farmers encounter challenges or barriers when enrolling and participating in EQIP?

3) What benefits and opportunities does EQIP participation provide to Vermont farmers?

4) Is the realized effectiveness of EQIP in Vermont aligned with the espoused program goals? If not, what changes could be made to improve that alignment?



## **CHAPTER 2: LITERATURE REVIEW**

### **2.1 Environmental Impacts of Agricultural Systems**

The environmental degradation and negative externalities imposed on society by US agricultural production systems have been steadily increasing since the end of World War II (UNCTAD, 2013). These impacts include soil erosion, pollution of waterways and groundwater, greenhouse gas emissions, loss of biodiversity, shrinking wildlife habitat, and pesticide and fertilizer run-off and leaching (Grossman, 2011). Current trends in population growth and demand for food continue to fuel the production, and exacerbate the impact, of these externalities (UNCTAD, 2013). Climate change further compounds these challenges; rising temperatures, increasing geographic and temporal variability of precipitation, extended growing seasons, and increasing frequency of extreme weather conditions are significantly impacting agricultural systems in a multitude of ways (Walthall et al., 2013). The need to ensure the resiliency and viability of our farms and food systems is a pressing and increasingly salient issue.

The following sections outline the impact of agricultural production on two major natural resources- water and soil. This is followed by a brief discussion of the impacts of climate change and variability on agricultural systems and an overview of agriculture in Vermont.

#### **2.1.1 Water & Agriculture**

Agricultural systems in the United States significantly impact both water usage and water quality. US agriculture accounts for 80-90% of all water use with 37% of the total is used specifically for irrigating crops (Osteen, Gottlieb, & Vasavada, 2012).

Simultaneously, water bodies and groundwater are contaminated by agricultural leacheates, surface run-off, and waste water disposal. Thus there is a need to address both water use efficiency and water quality (Osteen, Gottlieb, & Vasavada, 2012). The former can be addressed by improving water management practices, for example by upgrading irrigation systems. The latter can be addressed by improving water management practices through avenues, such as extension outreach, and policy changes, such as Vermont's renewed focus on total maximum daily load standards for phosphorus entering Lake Champlain (Osteen, Gottlieb, & Vasavada, 2012; <http://www.epa.gov/region1/eco/tmdl/lakechamplain.html>).

### **2.1.2 Soil & Agriculture**

Soil quality is a reflection of “the capacity of soil to facilitate nutrient cycling, regulate water flow, maintain physical stability, neutralize environmental pollutants, and provide habitat, food, and fiber (Osteen, Gottlieb, & Vasavada, 2012, p.33).” The higher the quality of the soil, the higher the resiliency of the land to environmental disturbances; this greater degree to mitigate the effect of pollutants and flooding equates to fewer negative externalities being imposed on society by farms with poor soil quality (Osteen, Gottlieb, & Vasavada, 2012). Additionally, in 2007 approximately 27% of the cropland in the US was classified as highly erodible (Osteen, Gottlieb, & Vasavada, 2012). Good soil quality and management decrease the rate of erosion and thus the amount of particulate matter entering waterways and airways (Osteen, Gottlieb, & Vasavada, 2012).

### **2.1.3 Climate Change & Agriculture**

Climate change has had, and will continue to have, a multitude of both beneficial and detrimental impacts on US agricultural systems (UNCTAD, 2013; Walthall et al., 2013). Crop growth is a function of temperature, precipitation, water availability, carbon dioxide levels, and solar radiation. Increasing temperatures and carbon dioxide levels will allow for faster, more vigorous plant growth however weed pressure and the plants' demand for water will simultaneously intensify (Walthall et al., 2013). Livestock health will likely be negatively impacted even as the production of their feed is positively affected (Walthall et al., 2013). The higher temperatures, resulting in more frost-free days, will likely disrupt pollination, lead to the need to shift away from crops or cultivars with certain temperature requirements, and cause changes in the regional composition of pest, pathogen, and weed species populations (Walthall et al., 2013). As precipitation increases and becomes more variable, erosion and run-off rates may increase and become more severe, especially on farms using conventional tillage and leaving ground fallow (Walthall et al., 2013). As droughts and high temperatures become more common, water shortages may cause costs of production to increase as irrigation becomes more expensive (Walthall et al., 2013). All told, the net effects of climate change on agricultural systems are, and will remain, highly heterogeneous and dependent on the many spatial, temporal, and biophysical variables of the agricultural system being examined.

#### **2.1.4 Brief Overview of Vermont Agriculture**

Vermont has 7,338 farms on 1,251,713 acres of cropland, woodland, and pastureland (2012 Census of Agriculture). The mean farm size is 171 acres (2012 Census of Agriculture). The hilly, rocky terrain is composed of a wide variety of soil types suitable for growing a variety of crops, although pastures and hay are predominant. Summer temperatures typically range from 51-82°F while winter temperatures tend to remain between 0-30°F ([www.agclassroom.org/vt](http://www.agclassroom.org/vt)). Dairy production accounts for 72% of the value of Vermont's agricultural products ([www.agclassroom.org/vt](http://www.agclassroom.org/vt)). Vermont's climate, terrain, and composition of its agricultural economy are similar to that of other Northeastern states but unlike that of the rest of the country. This directly influences the scale and product type of Vermont farms and the selection of management practices employed by Vermont farmers; each is different from that of farmers in other geographic location. This fact will be especially relevant in the ensuing discussion of incentivizing the adoption of best management practices by Vermont farmers.

### **2.2 Resiliency in Agricultural Systems**

Farmers need access to land and water in order to grow and sell their products and remain in business. The way in which each farmer chooses to manage their natural resource base is influenced by many factors including the farmers' educational background, public policies, and market forces (Osteen, Gottlieb, & Vasavada, 2012). In addition, farmers need to be prepared to adapt to a multitude of stimuli generated by climatic variability in the short run and climate change in the long run (Bryant et al.,

2000). Decisions made in all arenas and at all temporal scales will influence the viability of their operations (Smit, Burton, Klein, Richard, & Wandel, 2000). It is the hope that different temporal adaptations will be iterative and that short-term management strategies to deal with current environmental and climatic conditions will also improve farmers' ability to adapt in the long-term (Howden et al., 2007; Adger et al., 2005).

Resiliency is defined as "the degree to which a system rebounds, recoups, or recovers from a stimulus (Smit et al., 2000, p.238)." These stimuli may include changes to the physical, political, social, or economic farm environment (Smit & Skinner, 2002). Research has shown that farmers' adaptive responses to these changes tend to involve a modification of an existing agronomic practice they or their neighbors already employ (Smit & Skinner, 2002). Farmer demographics, market supply chains, the degree of system exposure and vulnerability, whether or not the change was anticipated, and the economic implications of the chosen strategy all influence what type and scale of adaptation is chosen and whether the adaptation is spontaneous or planned (Bryant et al., 2000; Smit & Wandel, 2006; Smit et al., 2000). Adaptive responses can be reactive or proactive and occur on many different scales ranging from individual farmer's actions to government interventions (Bryant et al., 2000; Smit & Wandel, 2006; Smit et al., 2000).

### **2.3 Best Management Practices**

This research focuses on farmer adoption of best management practices (BMPs), which is one option available to farmers who wish to adapt their systems to address on-farm natural resource concerns. The USDA defines BMPs as “established soil conservation practices that also provide water quality benefits (Gold, 2007).” Examples of common BMPs include cover cropping, stripcropping, and appropriate fertilizer application rates (Gold, 2007). Implementation of BMPs allows farmers to improve the overall resiliency of their land while simultaneously generating economic returns (Howden et al., 2007). For example, a farmer’s decision to adopt conservation tillage techniques leads to less erosion, reduced compaction, and improved moisture retention of their land; this reduces equipment, fuel, and labor costs while improving the long-term health of their soil and the resiliency of their land (Wall & Smit, 2005).

The USDA and other agricultural technical service providers are increasingly emphasizing the need for farmers to adopt BMPs to address environmental health concerns, ensure the long-term sustainability of their operations, and to use as an adaptation strategy for coping with climate change (Walthall et al., 2013). Bradshaw, Dolan and Smit (2004) emphasize the importance of regional field testing of best management practices to ensure the strategies are a suitable match for the type and size of farm operations for which they are being recommended. This research is part of an on-going effort in Vermont to examine what types of farms are using which best management practices, the outcomes of using those practices, and what governs farmers’ decisions to employ those adaptive strategies. The overall trends in the literature

examining farmer adoption of BMPs are discussed below in order to set the stage for this specific research project.

## **2.4 Farmer Adoption of Best Management Practices**

The decision-making processes surrounding farmers' management decisions are embedded in their social, biophysical, institutional, and economic environments (Wall & Smit, 2005). One way to understand farmers' patterns of adoption for agricultural innovations such as BMPs is through diffusion models. The best known is Everett Rogers' 1962 theory which outlines how innovations spread through society (Rogers, 2003). Central to Rogers' theory are the key categories of adopters which are separated according to speed of adoption into innovators, early adopters, the early majority, the late majority, and laggards (Rogers, 2003). Four characteristics of innovations- complexity, compatibility, trialability, and observability- are also integral to Rogers' (2003) explanation. Linking the characteristics of an innovation with the traits and avenues of communication used by adopters explains why certain innovations are adopted at a rapid rate, while others are not adopted or spread more slowly (Rogers, 2003).

Rogers' diffusion theory is the most widely utilized, however in 1981 Lawrence Brown published an alternative theory that has also been frequently applied. Brown held that the paths of innovation diffusion are dependent on the entity that supplies the innovation as that entity is in the position to regulate who the innovators and early adopters will be, thereby affecting the entire cycle of the diffusion process (Brown, 1981). While it is important to recognize Brown's contribution to diffusion theory, it is

not generally employed by diffusion scholars examining the spread of agricultural adaptation strategies. Due to their tacit nature, adaptive agricultural innovations do not fit well into Brown's supply management framework. In addition, adoption decisions about agricultural innovations tend to occur at the individual or household level instead of at the firm or distributor level (Feder & Umali, 1993). Therefore the majority of the literature focused on the diffusion of adaptations amongst farmers examines patterns by applying Rogers' model.

Many studies have examined the demographic and farm characteristics as well as the motivations of farmers who adopt best management practices. Although results vary with the methods employed, many trends of significant demographic variables and character traits exist in the literature. Farmers who have obtained higher levels of education, possess a higher degree of environmental awareness, and have more knowledge about the impacts of agricultural practices on the environment are more likely to implement BMPs than their peers (Prokopy, Floress, Klotthor-Weinkauff, & Baumgart-Getz, 2008; Ryan, Erickson, & De Young, 2003; Saltiel, Bauder, & Palakovich, 1994; Stock, 2007). BMPs are also more likely to be adopted by farmers whose peer networks support and promote the practices (Carolan, 2005). This indicates that innovations which mesh well with farmers' perceptions of self, socioeconomic status, and background and which preserve their primary source of social capital have a greater likelihood of being adopted (Carolan, 2005; Risbey, Kandlikar, Dowlatabadi, & Graetz, 1999). In addition, farmers with diversified operations and those who derive intangible value from the health of their land are more likely to implement BMPs (Prokopy et al., 2008; Ryan et al., 2003;



Wall & Smit, 2005). This is significant because sustainable agricultural practitioners by nature tend to be reflexive, rather than prescriptive, growers, a valuable quality given the unpredictability of the farming profession (Stock, 2007).

Due to the usefulness of Rogers' diffusion theory in linking the spread of innovations to adopter characteristics, researchers have most frequently studied the demographic characteristics of farmer adopters. However, a variety of farm structure, agroclimatic, and BMP characteristics have also been identified as significant variables influencing the adoption of BMPs by farmers (Camboni & Napier, 1993; Ryan et al., 2003; Salatiel et al., 1994; Webb, 2004). Both the overall farm structure and the specific enterprises the farmer is engaged in strongly influence the ease in which a BMP is adopted and integrated into the management system (Camboni & Napier, 1993; Salatiel et al., 1994). The BMPs which are most frequently adopted are generally low in complexity, highly compatible with the existing farm system, high in trialability, and high in observability (Webb, 2004). Farm scale is positively correlated to adoption, with larger farms more likely to adopt BMPs (Feder & Umati, 1993; Prokopy et al., 2008; Ryan et al., 2003). As scale increases, income level, capital, and hired labor also tend to increase; it follows that those three variables are usually positively correlated to BMP adoption as well (Prokopy et al., 2008; Ryan et al., 2003). The agroclimatic environment of the farm can also affect the adoption of BMPs and it follows that the relative influence of all of the variables identified above, as well as types of BMPs adopted, will vary by region (Feder & Umati, 1993; Webb, 2004). The failure of Knowler and Bradshaw (2007) to find any significant variables at the global level that could universally describe

adoption patterns or the motivations of farmers who adopt BMPs further suggests the need to use an appropriate scale when undertaking adoption research. This point will be important later in examining conservation program design and the need for regional specificity in order to maximize its effectiveness (Bradshaw et al., 2004; Knowler & Bradshaw, 2007).

## **2.5 Economic influences on decision-making**

The influence of demographic, farm, agroclimatic, and BMP characteristics on farmers' decisions to adopt BMPs should not be discounted yet the economics behind the choice to adopt influences decision-making more than any other factor. The practice needs to be profitable and the perceived risk associated with implementing the practice low enough in order for widespread adoption to occur (Camboni & Napier, 1993; Marra, Pannell, & Ghadim, 2003; Salatiel et al., 1994; Webb, 2004). Farmers implementing BMPs tend to create positive externalities in the form of ecosystem services; if the costs of implementation are greater than the private benefits produced, farmers are privately funding public goods (Kroeger & Casey, 2007; Lichtenberg & Smith-Ramirez, 2011). As public goods are non-rival and non-excludable, if farmers do not perceive enough of a threat to their farm systems to warrant adoption they will be better off financially not implementing a BMP regardless of any existing environmental concerns; this lack of proactive adoption can result in the underproduction of ecosystem services and is detrimental to both the farm operation and society (Cary & Wilkinson, 1997; Kroeger & Casey, 2007; E. Lichtenberg & Smith-Ramirez, 2011).

At the most basic level, a practice is profitable if the costs associated with implementation are less than the resulting benefits (Mendelsohn, 2000). Pannell (1999) takes this definition one step further and states that a practice should produce benefits that outweigh both the direct costs and opportunity costs of adopting that practice. Weighing the opportunity cost in the implementation decision can be especially important in farm systems where the value of time is at a premium. Time spent implementing a BMP may mean less time for other farm tasks and possibly less economic profit overall in the short term; this line of reasoning may be why many farmers perceive BMPs to be an “income drag” on their bottom line, regardless of whether that perception has any grounding in reality (Valentin, Bernardo, & Kastens, 2004). The difficulty in altering this perception lies in the fact that, though the costs are accrued in the short-term, the benefits of implementing BMPs may only be tangible in the medium or long term (Bradshaw et al., 2004; Pannell, 1999; Risbey et al., 1999). Crop yields are the most visible short-term performance measure of BMP adoption; however, just as yield is not always an accurate indicator of farm profitability, that measure does not always serve as a reliable indicator of long-term success for BMPs (Risbey et al., 1999). If the BMP is being implemented by a farmer who is examining the economic, environmental, and social sustainability of their farm at all temporal scales, measures of successful BMP adoption should examine the level of resiliency and long-term sustainability of the agricultural system (Risbey et al., 1999).

The other economic factor complicating farmers’ BMP implementation decisions is the influence of the perceived risks associated with adoption. The farmer needs to

perceive that the risk to the viability of their business, either at the environmental or farm level, outweighs the risk of implementing a new practice (Cary & Wilkinson, 1997). This can become a significant barrier to adoption as perceived profitability tends to trump environmental concerns in farmers' decisions (Cary & Wilkinson, 1997). If enough of a risk is perceived, the farmer then examines the realized and intangible costs, benefits, and potential effects of implementation on their operation (Marra et al., 2003). As discussed above, assessing this situation may prove challenging if it is unclear when the benefits and costs will actually accrue. This can leave the decision-making process largely dependent on the type and amount of information available about the practice and the degree of risk-averseness of the farmer (Marra et al., 2003; Mendelsohn, 2000; Pannell, 1999). As the need for adoption increases, farmers may also want to examine the possibility of joint BMP adoption in order to reduce the level of risk assumed by each individual implementing a particular practice (Mendelsohn, 2000). By taking collective action, it is possible to form a network of knowledge and technology sharing and implement regional solutions that benefit many farmers (Mendelsohn, 2000).

## **2.6 Incentives for BMP Implementation**

If the benefits of either individual or joint adoption do not outweigh the cost of implementation and affect the rate of BMP adoption, government intervention may be necessary. Federal incentivized conservation programs assist farmers in overcoming the economic barriers to BMP adoption, subsequently improving the long term profitability and resiliency of their operations (Bryant et al., 2000). These programs serve to

counteract the underproduction of public goods and encourage the prosperity of agricultural systems without compromising the health of the environment (Lichtenberg & Smith-Ramirez, 2011; Smith, 2006).

In order to achieve these goals, conservation programs address the two main economic barriers to farmer adoption of BMPs- profitability and the perceived risks of implementation (Camboni & Napier, 1993; Marra et al., 2003; Salatiel et al., 1994; Webb, 2004). Indeed, it has been shown that farmers' supply of conservation practices responds to changes in incentive payments. For example, Kurkalova et al. (2006) demonstrated that acreage in conservation tillage supplied increases with the level of subsidy offered per acre. Many other conservation practices, such as strip cropping, contour farming, terracing, and cover cropping have been found to have a positive elastic response to a 1% change in the cost of the practice to the farmer (Lichtenberg, 2004). This elasticity increased when complimentary combinations of practices were analyzed; incentivizing combinations proved to be cheaper, and yield more environmental benefits, than practices implemented in isolation (Lichtenberg, 2004). Farmers are also more likely to supply an ecosystem service when it is produced jointly with a marketable farm product (Wossink & Swinton, 2007). This willingness of farmers to supply ecosystem services when the practice is complementary, or even enhances, the rest of the business is further evidence that economics tends to trump social and environmental considerations in farmers' BMP adoption decisions.

Incentive payments compensate farmers for a portion of the direct implementation costs and include a risk premium to offset the uncertainty associated with adoption

(Cooper & Signorello, 2008; Kurkalova et al., 2006). Required components of incentive payments will vary in quantity from farmer to farmer as will the magnitude of the weight given to risk aversion, direct costs, and opportunity costs in their decision-making process; at times an individual's risk-aversion may be so strong that it prohibits adoption even when expected profits with BMP implementation are higher than those generated with the current management system (Kurkalova et al., 2006; Wossink & Swinton, 2007). Thus the challenge for formulating incentive levels is in finding a value high enough to increase the overall rate of adoption and low enough to maintain the cost-effectiveness of the conservation program (Feder & Umali, 1993). Few studies have calculated percentages that can be used to formulate appropriate incentive levels (see Cooper & Signorello, 2008 and Kurkalova et al., 2006 for examples). Determining accurate figures for farmers' willingness-to-accept (WTA) for implementing conservation practices is a key step in designing effective public policy and one that needs a continued regional research focus (Claassen et al., 2008; Cooper & Signorello, 2008; Wossink & Swinton, 2007).

## **2.7 Environmental Quality Incentives Program**

In response to the need to address environmental health concerns and correct the temporal and distributional inequities affecting farmer adoption behavior in the failing market for ecosystem services, in 1996 the federal government authorized the Environmental Quality Incentives Program (EQIP). The overarching goals of EQIP are to support the co-production of agricultural products and environmental quality and to

assist farmers in complying with the minimum standards of environmental regulations. It is important to note that EQIP is not the only USDA conservation program. The others include the Agricultural Management Assistance Program (AMA) and the Conservation Stewardship Program (CSP). This project focuses on EQIP because it has the highest rate of participation, funds the largest scope of projects, and may be utilized by a diversity of farm types.

Through EQIP, incentives are provided in the form of cost-sharing and technical assistance to farmers who wish to make structural improvements or implement BMPs. Natural resource concerns, such as water quality, soil erosion, air quality, energy conservation, and preservation of biodiversity, must be directly addressed by the project in order to qualify for funding. EQIP contracts may be one to ten years in duration and cover up to 75% of incurred expenses with cost-share funds. Payments are made to farmers upon completion of each project in their contracts.

EQIP needs to be effective at the farm-level while producing the results the government desires within the constraints of the allocated budget. Cost effectiveness at the federal level is tracked not only through total expenditures per acre but also by environmental benefit per dollar spent but the realized effectiveness of the program is dependent on far more than these two metrics. Three specific areas- funding, contract approval, and incentive payments- influencing to the cost-effectiveness of EQIP at the farm and federal levels are addressed below. Following that, the USDA's method of examining project results and its voluntary approach to conservation programs are discussed. This review of EQIP will conclude by identifying research needs.

### **2.7.1 EQIP: Funding**

USDA incentivized conservation programs are federally funded but implemented by state NRCS offices. Both NRCS and the conservation programs it administers are entrenched in the mandatory spending category in the USDA budget while funding for conservation technical assistance, a key part of program implementation, is categorized as discretionary funding (USDA, 2013). Each year conservation projects compose about 7% (\$1.4 billion in 2012) of the total USDA budget ([www.nrcs.usda.gov](http://www.nrcs.usda.gov)). In fiscal year 2011, that included 38,352 EQIP contracts approved or completed for a total of \$864,860,399 obligated for conservation projects on 13,162,935 acres across the United States ([www.nrcs.usda.gov](http://www.nrcs.usda.gov)). Vermont had 373 active or completed EQIP contracts on 42,589 acres funded with \$9.48 million dollars of federal incentive money ([www.nrcs.usda.gov](http://www.nrcs.usda.gov)). Despite increasing levels of funding since the program began in 1996, funding gaps have become a regular occurrence in recent years which in turn has affected program delivery (Eubanks, 2009). In addition, though EQIP is projected to be minimally affected, the 2014 Farm Bill reduces aggregate spending on conservation programs by \$4 billion over the next ten years. These funding gaps and reductions, coupled with the federal government's goal of maximizing environmental benefit per dollar expended, has contributed to the trend of NRCS targeting large farms with conservation money; the economy of scale rule dictates that contracts for large farms are more efficient at reducing environmental harm and have lower administrative transaction costs per acre than those for small farms (Eubanks, 2009). Annual funding is one way to



measure program health yet it is a one-dimensional metric and other components are needed add complexity to the examination of EQIP effectiveness.

### **2.7.2 EQIP: Contract Approval Process**

When farmers submit EQIP contracts, NRCS staff evaluate and approve program applications according to the environmental and resource concerns prioritized by the state as targets for program initiatives. A weighted environmental index is created and utilized to rank farmers' EQIP applications and determine which contracts will maximize environmental benefit per dollar expended. It is important to note that the environmental priorities the incentives will address are determined by government officials and state conservation service employees, not farmers (Johansson & Cattaneo, 2006; Smith, 2006). This is significant because it has been demonstrated that the form of these environmental indices affects the function and outcomes of EQIP; the weights assigned to environmental components represent trade-offs between, and government valuation of, various components of the state's natural resource base (Johansson & Cattaneo, 2006). It follows that appropriate regional indices would help ensure enrollment of farmers who are implementing practices that address the most pertinent environmental concerns in the area (Johansson & Cattaneo, 2006). Regional policies also provide specific incentives leading to targeted results instead of approving cost-shares for practices that are more effective at solving resource concerns in other regions of the country (Smith, 2006). In addition, regional indices may also benefit farmers by funding conservation practices that fit their farm systems, leading to the joint production of

ecosystem services and marketable products while simultaneously increase the aggregate adoption rate of BMPs (Wossink & Swinton, 2007).

### **2.7.3 EQIP: Cost-share Payments**

After an application is approved, a contract is offered to the farmer, outlining the cost-share and technical assistance NRCS can offer for the practices or structures the farmer wishes to implement. Economically, this is NRCS' demand curve for particular practices, or, stated otherwise, its willingness-to-pay (WTP) as a consumer of conservation services, and it varies according to regional environmental priorities (Kroeger & Casey, 2007). Unlike a traditional supply and demand model where the producers set the prices, in this case the farmers are price-takers and NRCS is both the consumer and the price-setter. Whether or not the farmer accepts the offer made by NRCS is largely dependent on their individual WTA. Plotting farmers' WTA generates a supply curve that can represent either acres managed using BMPs or the quantity of agri-environmental benefits produced as a result of the BMPs implemented (Kurkalova et al., 2006; Smith, 2006; Swinton, Lupi, Robertson, & Hamilton, 2007; Wossink & Swinton, 2007). It follows that the equilibrium point of these supply and demand curves represents the point where farmers' aggregate WTA and the government's WTP are equal, which would be an indication that EQIP is functioning effectively at both the farm and federal levels (Swinton et al., 2007).

As noted above, more research is needed to determine mean regional levels of WTA as demographic, geographic, farm characteristics, and degree of risk averseness directly affect the minimum support a farmer requires (Claassen et al., 2008; Wossink &

Swinton, 2007). If incentive payments are too low, the enrollment process might not be worth the farmers' time and low participation rates might affect the long-term viability of conservation programs. However, the cost effectiveness of the program, number of contracts funded, and the net environmental benefit generated by the program will decrease if the government offers cost-share amounts in significant excess of farmers' WTA (Claassen et al., 2008; Yano & Blandford, 2009). The latter situation has previously occurred in the Conservation Reserve Program; Claassen et al. (2008) found 10-40% of payments received were above the minimum amount farmers were willing to accept.

No simple solution appears to exist that would allow a straightforward reduction in the difference, for either excess or insufficient funds, between cost-shares offered and farmers' WTA. This is because there is inherently information asymmetry present in the relationship between farmers and NRCS staff (Cattaneo, 2003; Claassen et al., 2008; Yano & Blandford, 2009). Farmers can estimate their WTA based on their true costs, potential benefits, and expected risk. NRCS has rough estimates of costs and the awareness that a premium to offset risk should be included in the cost share (Cattaneo, 2003). Not only does this mean that NRCS' price schedule for structures and BMPs does not work for all farmers but it creates the potential for adverse selection (Cattaneo, 2003). For example, it has been found that cost-share incentives were actually functioning like income transfers when granted to farmers for whom adoption of a BMP would have been profitable or preferable even without incentive assistance (Horan & Claassen, 2007; Kurkalova et al., 2006; Lichtenberg & Smith-Ramirez, 2011). Thus, while there is

evidence that cost-share programs like EQIP do in fact increase the probability that farmers will implement conservation practices, there is clearly work to be done to ensure that incentive payments are cost-effective for both farmers and taxpayers (Lichtenberg & Smith-Ramirez, 2011).

#### **2.7.4 EQIP: Voluntary Approach to Conservation**

Farmers who choose to enroll in EQIP do so voluntarily. This approach is intended to leave the power to make management decisions with farmers, potentially increasing the program participation rate and reducing government expenditures for transaction and enforcement costs compared to mandatory standards (Horne, 2006; Khanna, 2001; Lal, 2004). However, it has been called into question as to whether farmers have enough flexibility with their time and resources to make a voluntary approach to conservation effective in the current US agricultural systems (Eubanks, 2011). Effectiveness could potentially be improved if programs focused more on outcomes rather than outputs (Winsten et al., 2011). The current system provides incentives for farmers to implement projects and practices; alternatively, result-driven incentives could be provided for farmers to achieve specific environmental outcomes (Winsten et al., 2011). That change would entail overhauling EQIP to more closely resemble the structure of the CSP. Such an evaluation is beyond the scope of this research, however it appears that this could provide farmers volunteering to enroll in EQIP a higher level of motivation to meet and exceed the minimum environmental standards while simultaneously maximizing the short and long-term benefits of the program at the farm-level (Winsten et al., 2011).

### **2.7.5 EQIP: Contract Outcomes**

In order to determine if the program components discussed above are generating the expected results and to improve the effectiveness of EQIP, completed contracts need to be monitored in order to determine what outcomes the program generates. Both the evaluation of environmental benefit, due largely to a lack of baseline data, and issues with contract monitoring are persistent problems for NRCS staff (Claassen et al., 2008). Performance measures currently used to evaluate EQIP include the number of nutrient management plans developed and acres of crop, grazing, and forested land managed with conservation plans ([www.nrcs.usda.gov](http://www.nrcs.usda.gov)). Quantitative environmental effect values drawn from the literature are then assigned to all components of these performance measures in USDA cost-benefit program evaluations. A more direct effort to identify and measure program outputs and outcomes was launched in 2005 when the Conservation Effects Assessment Program was established (Duriancik et al., 2008; Stubbs, 2010). However, results from this multi-organizational endeavor have been limited in scope and it remains unclear as to whether that data will establish causal linkages between implemented practices and environmental improvements at regional or farm scales (Duriancik et al., 2008). Smith (2006) suggests that the reason for these challenges is that funded projects attempt to improve many different environmental problems simultaneously; this presents practical measurement issues, leading to difficulties producing direct evidence that cost-share funds are generating the anticipated benefits.

It is also unclear whether projects are always carried out as contracted. This lack of clarity arises due to limited staff resources or incentives becoming perverse. If the

staff time is limited, project monitoring may not occur with adequate frequency. These situations necessitate federal and state NRCS staff take farmers at their word that contracts are being fulfilled (Cattaneo, 2003; Yano & Blandford, 2009). Limited staff time may also correlate to reasons behind why certain contract decisions do not seem to reflect the stated goals of EQIP. For example, in a survey of over 400 Maryland farms, there was no correlation between the applicants' proximity to water or specific environmental issues and the receipt of cost-share funds, despite Maryland's emphasis on cleaning up Chesapeake Bay (Lichtenberg & Smith-Ramirez, 2011). Yet, it appears that there is a new commitment to funding monitoring projects; although no monitoring and evaluation contracts were funded from 1996-2008, starting in 2012, \$482,144 has been allocated for 69 monitoring projects, 11 of which had been completed as of May 2013 (Natural Resources Conservation Service, 2013).

The second reason contracts may not always generate the intended program outcome is that, in some instances, incentivized contracts create situations of perverse decision-making. Incentives have been found to reduce the amount of farm acreage covered by vegetation and to increase production occurring on marginal land (Lichtenberg & Smith-Ramirez, 2011). Large farms, especially operations for which increased acreage means increasing returns to scale, may cause more environmental damage by increasing production on marginal land not previously included in their rotation (Eubanks, 2011; Yano & Blandford, 2009). It is not evident in the literature whether this is a common occurrence. Instituting a compliance reward system to counter any tendencies towards this form of systemic noncompliance may be necessary in some

areas and could be achieved by restructuring payments to encourage the generation of measurable performance-based program outcomes (Yano & Blandford, 2009).

#### **2.7.5 EQIP: Research Needs**

All of the program components discussed above frame various aspects of the ways farmers interface with EQIP. A complete examination of program effectiveness should also objectively examine the experiences of farmers participating in the program and the impact of their participation on their businesses. A 2010 survey elicited significant differences between the viewpoints of academics, government officials, NGO employees, and farmers as to whether EQIP is effectively fostering the implementation of sustainable agricultural practices (Bailey & Merrigan, 2010). Opinions of each group varied by practice, but overall only 73% of practices funded by EQIP were judged to be advancing environmental sustainability (Bailey & Merrigan, 2010). The reasons for this discrepancy with the espoused theory of the program are not addressed by the survey authors but may be embedded in the research of others. The difference could be rooted in farmers, academics, government officials, and NGO employees each subscribing to a different definition of sustainability. Farmers' perceptions of program accessibility may also have been affected by the fact that both average contract size and the number of unfunded applications have increased since program inception which could have decreased the perceived on-farm economic sustainability of EQIP (Stubbs, 2010). Additionally, in the first five-years of the program there was a 17% farmer withdrawal rate of approved contracts and practices. This potentially indicates that the contracts NRCS staff felt were encouraging sustainability either did not parallel farmers' definition

or fit their management systems (Cattaneo, 2003). To fully evaluate the effectiveness of EQIP, the shortage of research examining the program at the farm-level must be addressed.

As discussed above, this EQIP research should be conducted regionally in order to determine appropriate incentive levels and determine how effective the program is at the farm level. This research aims to provide that regional focus by examining three BMPs- conservation tillage, cover cropping, and conservation buffer strips- eligible for cost-sharing through EQIP. Though these are three among many different structural and conservation practices eligible for funding, after consultation with extension staff these three practices were selected based on applicability to a diversity of farm types in Vermont and the potential of each practice to help farmers address natural resources issues on their land while generating an indirect economic return. In the following sections, each practice is described and the benefits, costs, and ways each strategy improves the health of the environment while increasing the resilience of agricultural systems are identified.

## **2.8 Cover Crops**

Cover crops are grasses, legumes, or forbs planted by farmers in order to protect and improve the soil (NRCS, 2008). A diversity of temporal, spatial, and varietal options are available to farmers determining the cover cropping approach that best fits their farm system (Sarrantonio & Gallandt, 2003; Snapp et al., 2005). Examples of cover crops suitable to the climate in the Northeastern United States and commonly used by Vermont



farmers include winter rye, oats, peas, hairy vetch, and buckwheat (SARE, 2007; Sarrantonio & Gallandt, 2003). Farmers choose among these and other types of cover crops and determine whether to interseed, cover fallow ground in-season, or seed down a cover for the winter (SARE, 2007; Sarrantonio & Gallandt, 2003). Ultimately, varietal traits must be matched with the farmer's management goals, field availability, financial resources, and mechanical capabilities (SARE, 2007; Snapp et al., 2005). An in-depth discussion of cover cropping options is beyond the scope of this project; the focus will be on the benefits and costs of cover cropping and the role of the practice in increasing farms' resiliency.

The benefits of cover cropping can be divided into two main categories- agri-environmental and economic- and can be reaped by both the farmer and the general public (Sarrantonio & Gallandt, 2003; Snapp et al., 2005). Agri-environmental and economic benefits tend to form a positive feedback loop; the money invested in planting cover crops is generally repaid in agronomic and nonmonetary benefits in the long-term (Snapp et al., 2005). This interconnectedness generates systemic benefits which increase the ability of a farm to withstand variable changes in the environment (Snapp et al., 2005).

Many agri-environmental benefits of cover cropping are generated as the practice both conserves and improves the physical structure of the soil. The roots of cover crops hold soil in place while the above-ground plant biomass protects the soil from the impact of precipitation, significantly reducing erosion due to wind, water, and run-off (Frye & Blevins, 1989; Hartwig & Ammon, 2002; SARE, 2007; Sarrantonio & Gallandt, 2003).

Cover crops aid in increasing soil organic matter and improving soil structure which in turn improves infiltration capacity, conserves moisture, and reduces nutrient leaching (Frye & Blevins, 1989; Hartwig & Ammon, 2002; SARE, 2007; Sarrantonio & Gallandt, 2003). Leguminous cover crops not only uptake leaching nutrients but also capture and fix available nitrogen (SARE, 2007; Snapp et al., 2005). In cover cropped areas, Wyland et al. (1996) demonstrated a 65-70% reduction in nitrate leaching, an increased availability of nitrogen to the cash crop, and higher broccoli yields compared to the winter fallow plots. Similarly, Frye and Blevins (1989) found that using a legume cover crop with minimal tillage increased corn yields compared to systems involving a winter fallow period and use of synthetic fertilizers. Other agri-environmental benefits of cover cropping may include weed suppression and decreased incidence of pests and disease (Frye & Blevins, 1989; Hartwig & Ammon, 2002; SARE, 2007; Sarrantonio & Gallandt, 2003; Snapp et al., 2005).

This multitude of agri-environmental benefits generated by cover cropping leads to the increased sustainability of both the farmland and the surrounding environment (Sarrantonio & Gallandt, 2003). Reducing soil erosion and nutrient run-off improves water quality and soil health throughout watersheds (Hartwig & Ammon, 2002; Sarrantonio & Gallandt, 2003). Improving nitrogen availability, soil tilth, and soil organic matter may lead to a decreased need for application of synthetic fertilizers, weed suppression may reduce the need for herbicides, and pest and disease control can potentially mean less use of pesticides and fungicides (SARE, 2007; Sarrantonio & Gallandt, 2003). As a result, farmers receive a direct economic benefit while

simultaneously improving the health of the surrounding environment and increasing the resiliency of their land.

Although planting cover crops has been shown to be beneficial to agricultural systems, management decisions necessitate weighing the costs against the benefits. Specific direct costs accrued in most cover cropping systems include: land preparation, seed and seeding, a method of killing the cover crop (i.e mowing, herbicides, tilling) and incorporation (Tourte, Buchanan, Klonsky, & Mountjoy, 2003a). These categories are generalizable to many farm types and sizes yet realized costs are highly variable among farms; for example, a small vegetable farm may find cover cropping much more expensive on a per acre basis than a large dairy farm (H. Darby, personnel communication, November 9, 2012). Estimates range from \$45 to \$65 per acre for a large dairy farm and up to \$70 per acre for a farm performing primary tillage before seeding (Tourte et al., 2003; H. Darby, personnel communication, November 2, 2012). Reflecting this fact, the SARE publication *Managing Cover Crops Profitably* (2007) does not provide a specific budget for cover cropping but instead provides information to guide farmers as they explore cover cropping options. Wyland et al. (1996) also report general budget guidelines, specifically that the cost of winter cover cropping in their system was 5% of the cost of growing the cash crop that followed the cover and that 14% of the total cost of the cover would have been incurred in routine maintenance of a fallow field. It is thus important for farmers to consider their available resources, farm size, and management goals as they create cover cropping expense budgets tailored to their individual operations.

Despite the variation between farms, the direct costs of cover crop establishment are fairly straightforward to compile compared to the indirect costs, opportunity costs, and associated risks of implementation; these are also important factors in farm management decisions and provide some insight into why providing incentive payments for cover cropping can be helpful in promoting the adoption of the practice (Sarrantonio & Gallandt, 2003; Snapp et al., 2005). Indirect costs of cover cropping may include interfering with planting schedules, issues with cover crop management and incorporation, and resource competition between the cover and cash crop (Hartwig & Ammon, 2002; Sarrantonio & Gallandt, 2003; Wyland et al., 1996). The opportunity cost of cover cropping may be significant if the decision is made to plant the cover at a time when the field could be used for a cash crop (Sarrantonio & Gallandt, 2003). Farmers, especially those lacking experience with this BMP, must weigh the risk of a cover crop interfering with their management plans and expected profits against the potential benefits of planting; here again the balance of short-term profits with long-term sustainability is at the root of the adoption decision (Sarrantonio & Gallandt, 2003). If the direct costs to the farmer are greater than the perceived private benefits, cost-shares are needed to incentivize farmers to look beyond the short-term constraints and adopt this BMP (Snapp et al., 2005). Cover cropping is one of many BMPs that qualify for cost-sharing under EQIP.

## **2.9 Conservation Tillage**

Conservation tillage is a best management practice that leaves at least 30% of crop or cover crop residue remaining on the surface of the soil when the field is prepared for planting (Gold, 2007). No till and zone tillage systems are the two types of conservation tillage that will be discussed here. The practices and specific costs associated with each vary and will be addressed separately but the ways each approach helps farmers adapt to climate change is similar and will be discussed together.

Conservation tillage involves preparing land for planting without the use of conventional tillage implements such as plows or disks. Many farmers choose to kill the cover crop using an herbicide but this can also be achieved by crushing and flattening the cover crop using a roller-crimper, cultipacker, undercutter, or mower. In a no-till operation, a specialized seeder or transplanter is then used to rip a narrow strip through the cover crop into which the seeds or transplants are dropped (Rodale Institute, 2011). In contrast, zone tillage disturbs slightly more of the total ground surface (about 1/3) as 6-10" wide strips are tilled into the cover crop mat. Strip depth is typically 4-6" although deep zone tillage rips below the 6" plow pan and may penetrate as deep as 22". Crops are then seeded or transplanted into the tilled strips (Idowu, Rangarajan, van Es, & Schindelbeck, n.d.; Rangarajan, 2011). Zone tillage has the potential for farms using low-input and organic practices to get the combined benefits of no till and conventional tillage practices (Idowu et al., n.d.; Rangarajan, 2011). Both systems of conservation tillage provide many agri-environmental and economic benefits to agricultural operations.

Conservation tillage generates agri-environmental benefits by fostering soil conservation and improving the physical structure of the soil. Reduced tillage activity and the plant residue left on the surface significantly reduce erosion from both water and wind (Rodale Institute, 2011; Uri, 2001). Soil structure improvements are evident in the increased microbial activity and higher soil organic matter content; this means higher quality soil tilth and aggregation which allows for improved drainage and nutrient retention (Rodale Institute, 2011; Uri, 2001). In addition, the cover crop residue left on the surface of the soil retains moisture, regulates soil temperature, and suppresses weeds (Rodale Institute, 2011; N. D. Uri, 2000). These benefits improve the overall resiliency of soil and crops throughout growing seasons as well as during and after extreme weather events (Ding, Schoengold, & Tadesse, 2009; Idowu et al., n.d.; Rangarajan, 2011).

The direct costs accrued when generating this multitude of benefits vary with farm type, farm size, management type, and which type of conservation tillage is chosen (Howitt, Catala Luque, De Gryze, Wicks, & Six, 2009; N. D. Uri, 2000). Typical budget items for conservation tillage include: labor, fuel, equipment maintenance, and chemical inputs, if applicable to the farm system (Rodale Institute, 2011; N. D. Uri, 2000).

Equipment costs for conservation tillage systems can range from \$5,000-30,600 and so are significant factors in adoption decisions, however in most implementation budgets, purchased equipment is not included due to the high level of variability between farms (Grubinger, 2012; Rodale Institute, 2011). Specific costs, for growing corn and soybeans using a no till system, range from \$142-167 per acre using conventional practices and \$175-258 per acre using organic practices (Uri, 2000; Rodale, 2011). Organic growers

tend to incur higher costs than conventional farmers due to additional weed control and labor costs (Howitt et al., 2009).

Less detailed cost studies are available for zone tillage although Uri (2000) estimated a cost of \$140-190 per acre for ridge tillage, a similar practice. Costs for zone tillage likely have greater variability as the practice can be implemented on a wider diversity of farm types and sizes than no till systems. More general savings estimates, which farmers can apply to their own budgets when considering zone tillage, have been calculated at a 37% savings on labor and a 40% savings on fuel for zone tillage compared to conventional tillage (Rangarajan, 2011).

Indirect and opportunity costs should also be considered in farmers' decisions regarding the adoption of conservation tillage practices. Implementing this BMP may create challenges with weed control, cover crop residue management, delayed soil warming in the spring, and competition of the cover crop with the cash crop for water and nutrients, all of which can impact the yield of the cash crop (Grubinger, 2012; Idowu et al., n.d.; Rodale Institute, 2011; Uri, 2000). In addition, there is a steep learning curve associated with implementing a conservation tillage system which can initially negate the time saved with fewer passes in the field (Grubinger, 2012; N. D. Uri, 2000). This additional management and learning time comprise the main opportunity cost of using conservation tillage practices (Uri, 2000). Even when this opportunity cost is minimized and the expected profit with conservation tillage is higher than that realized using conventional tillage, risk averse farmers may be deterred from adopting this BMP and incentives of at least 13% of the expected return per acre may be needed to promote

adoption (Kurkalova et al., 2006; N. D. Uri, 2000). Conservation tillage is a highly beneficial but highly management and capital intensive system and cost-shares offered through EQIP are likely to increase the number of farmers implementing this BMP.

## **2.10 Conservation Buffers**

Conservation buffers are strips or areas of land permanently maintained in vegetation that primarily serve to intercept and filter sediment and pollutants in agricultural run-off (Gold, 2007). Types of buffers include: “riparian buffers, filter strips, grassed waterways, shelterbelts, windbreaks, living snow fences, contour grass strips, cross-wind trap strips, shallow water areas for wildlife, field borders, alley cropping, herbaceous wind barriers, and vegetative barriers (Gold, 2007).” Buffer strips may be established with annual grasses, perennial grasses, or a multi-species mix that includes grasses, shrubs, and trees (Rein, 1999; Schultz et al., 1995). An in-depth discussion of each type is beyond the scope of this project so the following will apply to conservation buffers in general.

There are many variables to consider when establishing conservation buffers. Decisions and designs will be dependent on specific management goals and field characteristics. It is common for areas planted to buffers to be marginal land with a high rate of erosion, low productivity, and bordering a water body and/or field edge (Nakao, Sohngen, Brown, & Leeds, 1999; Schultz et al., 1995; Tourte, Buchanan, Klonsky, & Mountjoy, 2003b). The width of the buffer has been identified by many as the most important factor in buffer strip effectiveness; width will vary from 10-15 feet on flat field



edges to 30-150 feet along riparian areas (Lowrance, Dabney, & Schultz, 2002; Tourte et al., 2003b). Slope, soil properties, field size, tillage practices, intensity of precipitation events, and orientation of the buffer strip with the field all affect how wide an effective buffer strip should be and also help inform the appropriate species composition (Qiu, 2003; Rein, 1999; Schultz et al., 1995; Tourte et al., 2003b; Yang & Weersink, 2004). Appropriate species will vary regionally and with the specific benefits the buffer is being managed to produce (Lowrance et al., 2002).

Conservation buffers provide a wide range of benefits that increase the adaptive capacity of farmland and surrounding watersheds. Planting buffer strips slows down surface water run-off, trapping the sediment, nutrients, and agro-chemicals that would otherwise be transported into the watershed (Lovell & Sullivan, 2006; Schultz et al., 1995; Tourte et al., 2003b). NRCS estimates that buffer strips can remove about 50% of nutrients, 50% pesticides, 60% of some pathogens, and 75% of sediment from run-off (Gold, 2007). Results from other studies vary but the same trends are evident. Qiu (2003) found that buffers reduced sediment by 25-35% and reduced nitrogen, phosphorus, and atrazine by 15%. During normal rainfall events, *E.Coli* removal through buffers has reached levels ranging from 94.8-99.995% (Tate, Atwill, Bartolome, & Nader, 2006). Tufekcioglu et al. (2003) and Schultz et al. (1995) found that in a multispecies riparian buffer 37 kg/ha/yr of nitrogen was immobilized, preventing excess nitrogen from leaching into the watershed.

In addition to the capacity to filter and immobilize nutrients, and agrochemicals, buffer strips significantly reduce erosion as plant roots stabilize streambanks, trap

sediment, improve water infiltration capacity, and serve as windbreaks (Lovell & Sullivan, 2006; Schultz et al., 1995; Tourte et al., 2003b). This increases the resilience of farmland and streambanks during severe storms and flooding events (Rein, 1999; Schultz et al., 1995). Other agri-environmental benefits of buffer strip include the creation of habitat for beneficial insects, regulation of water temperature, and carbon sequestration and storage (Lovell & Sullivan, 2006; Lowrance et al., 2002; Rein, 1999). In addition, farmers may choose dual purpose species that simultaneously benefit the environment and allow for a harvest of biomass for energy, hay, or timber; this practice not only offsets the cost of buffer implementation but diversifies the income streams, thereby increasing the resiliency of the farm (Schultz et al, 1995; Ohio State, 1999).

These agri-environmental benefits generated by buffer strip implementation are beneficial to both farmers and society. Reducing run-off and stabilizing field edges and riverbanks preserves the quality of drinking water supplies and decreases the cost of maintaining water sources and roadways and the expenses incurred cleaning up after severe weather events (Lovell & Sullivan, 2006; Rein, 1999; Tate et al., 2006). Indirect economic benefits to society include the aesthetic value of buffer strips on agricultural landscapes and an improved environment for both terrestrial and aquatic species (Lovell & Sullivan, 2006; Rein, 1999; Schultz et al., 1995). Though it is possible for buffer strips to become saturated, if properly constructed these projects can serve as a renewable means of environmental remediation that offset implementation costs in the form of long-term public and private benefits (Lovell & Sullivan, 2006)

The direct costs of establishing a conservation buffer strip have been tracked by many researchers; budgets are fairly uniform in terms of inputs included and assumptions made. Cost categories in buffer strip budgets generally include: seed or seedlings, land preparation, planting, and maintenance expenses (Nakao et al., 1999; Rein, 1999; Tourte et al., 2003b). Land preparation may include grading, disking, fertilizing, liming, and/or herbicide application (Nakao et al., 1999; Tourte et al., 2003b). Maintenance expenses vary according to the farm system and the species planted and can involve clearing brush, mowing, re-seeding annuals, irrigating, mulching, and/or harvesting hay or timber (Nakao et al., 1999; Tourte et al., 2003b). Neither fixed nor opportunity costs associated with land use conversion are included in any of the following estimates as these are highly variable among farms and are assumed constant regardless of whether or not the land is planted to buffer strips. Farmers may want to consider adding those land costs into their budgets; converting marginal land to buffer strips may potentially save money while highly productive land used as a buffer strip may negatively impact the bottom line (Nakao et al., 1999; Qiu, 2003). It is also important to consider that the majority of time and money required in the following budget estimates is required in the establishment phase.

Variability exists in conservation buffer cost estimates due to differences in the size, type, location, and management system of farms as well as the specific type and size of buffer strip being implemented. The following are estimates found in the literature for establishment costs. For most systems, expenses incurred in subsequent years will be significantly lower relative to the establishment year and will primarily include mowing,

harvest, or other maintenance needs. The numbers that follow do not include the costs of herbicides, mulch, irrigation, or fixed costs for land and machinery. Estimated costs to establish buffer strips composed of annual grasses range from \$126/A to \$470/A (Rein, 1999; Tourte et al., 2003b). Perennial grass buffer strips tend to have higher seed costs but be less expensive to maintain than annual grass buffers. According to five different studies, the cost of perennial buffer strips ranges from \$51.85/A to \$650/A, with an average expected cost of \$225.89/A (Nakao et al., 1999; Qiu, 2003; Rein, 1999; Tourte et al., 2003b; Yang & Weersink, 2004). The cost of establishing a multi-species buffer strip is likely higher than establishment with annuals or perennials; trees and shrubs tend to be significantly more expensive than grass seeds (Nakao et al., 1999). Farmers may want to amortize the costs of establishment over the lifetime of the vegetation and adjust the above budgets accordingly to account for buffer and farm specific variables in expenses (Qiu, 2003; Rein, 1999).

To fully examine the feasibility of buffer strip implementation for their operation, farmers should also consider the indirect and opportunity costs involved. Indirect costs of not establishing a conservation buffer may include continued expenses due to soil erosion and flooding damage (Lovell & Sullivan, 2006). Other indirect costs of implementation include the buffer strip harboring pests, shading crops, or creating physical barriers that increase travel time with equipment in the fields (Lovell & Sullivan, 2006; Qiu, 2003; Tourte et al., 2003b). The most significant opportunity cost associated with buffer strip implementation is that incurred when taking land out of production (Lovell & Sullivan, 2006; Nakao et al., 1999; Qiu, 2003; Tourte et al., 2003b). If

productive land is converted to buffer strips estimates of lost profits, for land in corn and soybean rotations, range from \$55.68/A to \$120/A (Nakao et al., 1999; Qiu, 2003).

However, often this opportunity cost is negligible as prime land for buffer strips tends to be low-lying, marginally productive land prone to erosion and ceasing to crop it can actually be more profitable for farmers (Nakao et al., 1999; Schultz et al., 1995; Tourte et al., 2003b). Incentive payments are available through EQIP to partially offset the direct cost of buffer strip establishment and reduce the impact of these indirect and opportunity costs.

### **2.11 Conservation practice implementation in Vermont**

According to the 2012 Census of Agriculture, in Vermont there are 25,452 acres managed with conservation tillage practices and 20,120 acres planted with cover crops annually (2012 Census of Agriculture, Table 50). The total number of acres tilled with either conventional or conservation tillage was 113,602; this equates to approximately 22% of that acreage managed with conservation tillage and close to 18% being cover cropped (2012 Census of Agriculture, Table 50). The total number of acres in buffer strips on farms is not among the data collected by this census. Though certain geographic and farm characteristics might limit the ability of Vermont farmers to match the implementation rates of some BMPs, such as conservation tillage, to that of farmers in the mid-West (for example, in Iowa 67% of tilled acreage is managed with conservation tillage), clearly there is the capacity for these, and other, BMPs to be implemented on a larger number of acres in Vermont (2012 Census of Agriculture, Table 50).

## **2.12 Research Needs**

The adoption of best management practices improves the agronomic health of the land while increasing its resilience to environmental disturbances. Though there are a variety of demographic, geographic, and other variables correlated to farmer adoption of BMPs, the primary determinant is economic. If the private benefits do not outweigh the direct, indirect, and opportunity costs incurred with adoption, it is unlikely that a farmer will choose to implement that BMP. To correct this market failure and encourage the coexistence of agricultural and environmental systems, the USDA offers incentivized conservation programs to offset the cost of BMP implementation. EQIP, the largest of these programs, provides cost-share funds and technical assistance to farmers implementing projects which address a regional resource concern. In order for the program to affect environmental change and increase the resiliency of farms, EQIP must be a cost-effective process that generates positive outcomes for both farmers and the government. Regional specificity is needed in examining conservation program implementation and the appropriate incentive levels required for farmer adoption of BMPs. This research aims to fill these gaps in the following two ways.

The first article estimates the incentive levels desired by Vermont farmers for implementing three common best management practices. Conjoint analysis is used to examine the preferences and WTA incentive levels of Vermont farmers for implementing conservation tillage, cover cropping, and conservation buffer strips. Calculated WTA figures are compared to historical EQIP cost-share payments for these BMPs. The relative importance of each attribute in farmer decision-making will also be evaluated.

Alternatives simulated options farmers have available to them when considering which BMPs to implement and whether the conservation incentives offered by the USDA meet their needs.

The second article examines the effectiveness of EQIP from Vermont farmers' perspectives. Survey questions were developed with the goal of documenting Vermont farmers' use of conservation practices and their experiences, or choices not to engage, with EQIP. Challenges and barriers to, as well as non-monetary benefits derived from, participation in the program are explored. Opinions about program design were also elicited. Results offer insight into whether EQIP effectively produces its espoused outputs and outcomes, identify the program areas that improvement efforts should target, and inform suggestions for farmers deciding whether or not to engage with the program.

## **CHAPTER 3: CONJOINT ANALYSIS OVERVIEW**

### **3.1 Stated Preference Approaches**

Stated preference approaches to determining respondents' preference structures can be broken down into three groups. The end result of these analyses is most often the derivation of part-worth utilities, or "a value that explains how important the respondent finds each attribute (Alriksson & Öberg, 2008, p.245)." Compositional methods use self-explication to directly elicit the part-worth of a good or service by respondents (Green & Srinivasan, 1990). Contingent valuation is the most common compositional method and results in stated levels of willingness-to-pay (WTP) or willingness-to-accept (WTA) for respondents' demand or supply of a non-market good (Alriksson & Öberg, 2008). The second group is composed of decompositional methods which derive, or decompose, the part-worth of a good or service according to the responses elicited from descriptions provided about the good or service (Alriksson & Öberg, 2008; Green & Srinivasan, 1990). The most common decompositional approach is conjoint analysis, the different forms of which will be discussed in detail below. The third type of stated preference approach are hybrid models that combine features of compositional and decompositional methods; in general, these hybrids are thought to generate results that are more robust than compositional results but less robust than decompositional approaches (Green & Srinivasan, 1990).

Conjoint analysis is the type of decompositional stated preference approach chosen for this research. This method was developed in 1964 by Luce and Tukey and was first used in the field of marketing. Green and Srinivasan have made significant



contributions to the evolution of this method and define conjoint analysis as “any decompositional method that estimates the structure of a consumer’s preferences given his/her overall evaluations of a set of alternatives that are prespecified in terms of levels of different attributes (Green & Srinivasan, 1978, p.104).” Respondents must evaluate the trade-offs inherent in the presented alternatives and then express their preferences for different options (Alriksson & Öberg, 2008; Green, Krieger, & Wind, 2001). The part-worths that are calculated as a result assume that respondent utility is a function of the attributes of the good or service (Alriksson & Öberg, 2008). Applications of conjoint analysis include generating information about the differences and appeal of goods or services, the relative importance of specific product attributes, the WTP or WTA of consumers for the good or service, and informing public policy decisions (Cattin & Wittink, 1982; Green & Srinivasan, 1978, 1990). Conjoint analysis most often involves one of the types of choice modeling; although hierarchical and hybrid methods are also options to consider, only choice modeling is relevant to this research and the focus will remain on this approach.

### **3.2 Designing a Choice Model**

The design of a choice modeling experiment involves five major steps. First, the researchers must determine the attributes of interest for each alternative good or service which will be presented to respondents. Selection of attributes can be informed through a combination of literature reviews, consultation with experts in the field, and focus groups with the target audience or consumers (Cattin & Wittink, 1982; Hanley,

Mourato, & Wright, 2001). Generally, attributes are chosen which are realistic, demand or supply relevant, have policy implications, and are believed to be important to the target audience (Alriksson & Öberg, 2008; Blamey, Bennett, Louviere, Morrison, & Rolfe, 2002; Cattin & Wittink, 1982; Hanley et al., 2001). The levels of interest of the chosen attributes are then specified. Many times the number of attributes and levels generated is too large to allow for the use of a full factorial design and to maintain accuracy in data collection; if this is the case a fractional factorial design, specifically an orthogonal array, is used to reduce the number of attributes and levels that will be presented to respondents (Green & Srinivasan, 1978, 1990). Orthogonal arrays eliminate less preferable levels of attributes by assuming that those levels will never be selected by respondents over attributes with levels that provide higher levels of utility (Green & Srinivasan, 1978). It is important to note that orthogonal arrays only address the main effects of attributes; all interaction effects between attributes are excluded and the resulting part-worth utilities assumed to be an additive function of individuals' preferences (Green & Srinivasan, 1978, 1990; Louviere, Hensher, & Swait, 2000). Despite this exclusion, research has shown that limiting the number of attributes and levels presented to respondents using orthogonal arrays generates accurate and robust results (Green & Srinivasan, 1990).

Once the composition of products or scenarios has been finalized, a method should be selected to present the alternatives to respondents. The two main approaches are the full profile and the two-factors-at-a-time methods; hybrids of these two methods are also utilized by many researchers however discussion of these options is beyond the scope of this project. The two-factors-at-a-time approach allows respondents to evaluate

the trade-offs between pairs of products or scenarios and then rank the pair in order of their preference; this approach allows for isolated evaluation of two attributes at a time (Green & Srinivasan, 1978). The full profile approach is most commonly used and involves presentation of all options to respondents to be evaluated simultaneously (Cattin & Wittink, 1982; Wittink & Cattin, 1989). This method is generally regarded as simulating a more realistic decision-making environment for respondents even though it is a considerably more complicated methodological undertaking (Cattin & Wittink, 1982; Green & Srinivasan, 1978; Wittink & Cattin, 1989). Though the number of options used successfully in studies has varied widely, in order to generate robust results it is recommended that a maximum of three to five attributes are presented in a random order in each full profile conjoint survey (Alriksson & Öberg, 2008; Green & Srinivasan, 1978). Presentation of alternatives may be through personal interviews, written information, phone interviews, photographs, or use of the actual product; each medium possesses its own benefits and challenges (Cattin & Wittink, 1982). If the geographic distribution of the target population permits usage, in-person interviews tend to be the most common and reliable form of data collection in conjoint studies (Wittink & Cattin, 1989). When the target population is widely disbursed, mail or phone surveys may be relied upon but tend to have lower response rates and pose an addition challenge in the ability of respondents to understand the task at hand (Wittink & Cattin, 1989).

With the presentation approach selected, the next step to choose a response mode, or type of choice modeling approach. One option is a choice experiment in which respondents choose their preferred alternative from a series of options, one of which is

the status quo; however results of a choice experiment can only be analyzed at the aggregate level (Alriksson & Öberg, 2008; Hanley et al., 2001). The paired comparison method expands on the choice experiment structure by having respondents choose their preferred alternatives and then rate the strength of each choice (Alriksson & Öberg, 2008; Hanley et al., 2001). Two of the most commonly used response modes are contingent rating and contingent ranking. When using the contingent rating approach, respondents are given a scale with which to independently rate each alternative presented to them (Alriksson & Öberg, 2008; Hanley et al., 2001). Contingent ranking requires respondents to rank the alternatives according to their preferences. The response mode chosen will depend on the goal of the study, the product or scenario to be evaluated, and the type of data analysis planned (Alriksson & Öberg, 2008).

There is much debate over the benefits and limitations of the contingent rating method compared with the contingent ranking approach. While using a rating scale characteristically allows for the more explicit comparison of the degree of difference between attribute levels, this determination of relative importance has also been applied in ranking surveys as well (Louviere et al., 2000). Rating scales have been found by some researchers to have advantages during statistical analysis of conjoint results (Alriksson & Öberg, 2008; Louviere et al., 2000). However, because alternatives are not being directly compared to each other, the translation of a respondent's product or scenario rating into actual market-based choices can be an issue (Hanley et al., 2001). Due to this fact, contingent rating tends to be less frequently employed in environmental studies focused on estimating citizens' WTP but is generally a more common method in

marketing studies (Hanley et al., 2001). Contingent ranking, which is based on Random Utility Theory, is considered to be the conjoint method that most accurately simulates an actual market-based choice environment for respondents (Hanley et al., 2001; Louviere et al., 2000; Louviere, 1988). Disadvantages of the ranking method include the possibility of respondents becoming fatigued or having difficulty while ranking alternatives (Hanley et al., 2001). In addition, the question arises as to whether respondents' part-worth utilities for each attribute would be consistent if the product or scenario profile presented were altered (Louviere et al., 2000). Here again, the resolution of the debate between advantages and disadvantages of response choices is dependent on study-specific goals, resources, and the specific products or scenarios in question (Alriksson & Öberg, 2008).

Following the response mode selection and data collection, a specific conjoint model should be chosen. Vector, ideal-point, and part-worth are the three types of models from which researchers can make their selection. Vector models integrate weights for respondents' degree of importance for each attribute, are linear in form, and tend to generate the fewest number of parameter estimates of the model options (Green et al., 2001; Green & Srinivasan, 1990). Ideal-point models apply an inverse relationship of preference and maximum utility to generate a concave graph that identifies the highest level of preference for each attribute (Green et al., 2001; Green & Srinivasan, 1990). In a part-worth model, the average part-worth utilities of each attribute are estimated; these part-worths can then be summed to estimate the part-worths for each product or scenario of interest (Green et al., 2001; Green & Srinivasan, 1990). The majority of conjoint

studies use the part-worth model due to its flexibility and its ability to estimate the greatest number of parameters (Green et al., 2001; Green & Srinivasan, 1990).

### **3.3 Validity and Reliability Issues**

Regardless of the specific model, response mode, and presentation style chosen for a conjoint study, there are issues of validity and reliability to consider. The main factors that lead to specific design and analysis options being selected are the same factors that affect the validity and reliability of the results. Broadly stated, these main factors are the type of problem, product, or scenario being examined, the attributes included in the survey, and the background and education level of the respondents (Blamey et al., 2002). The impact of the factors affecting the internal validity of conjoint results include selection bias, response bias, fault in survey design and presentation, and failure to accurately interpret the results and can be more easily minimized than external validity issues (Alriksson & Öberg, 2008). Specifically, survey design and presentation, when alternatives are overly complex or too numerous, can lead to respondent fatigue or confusion, diluting the actual meaning of the results (Hanley et al., 2001).

External validity and reliability issues are more often cited as significant considerations in conjoint studies. Many times these issues arise due to the difficulty in conjoint methods generating the same results more than once, researcher-driven (as opposed to respondent-driven) decisions in the number and type of attributes included in the survey, and the lack of transparency in the decision processes of respondents (Alriksson & Öberg, 2008; Hanley et al., 2001). The latter can be at least partially

remedied by inclusion of demographic and values-based questions along with the conjoint presentation (Garrod & Willis, 1997). Comparing the stated preferences collected with the survey instrument with the revealed preferences of the respondent and including tests to track the consistency of an individual's responses are frequently used methods of testing the external validity of the results (Green & Srinivasan, 1978; Hanley et al., 2001). When these validity and reliability issues are addressed throughout the conjoint analysis process, the literature shows that conjoint analysis can generate results that have predictive validity in the market and, subsequently, supply valuable data to inform policy decisions (Green & Srinivasan, 1990; Hanley et al., 2001; J. L. Louviere, 1988).

## **CHAPTER 4: METHODS**

### **4.1 Article 1 Methods**

#### **4.1.1 Data Collection**

Data for this project was collected using two different survey instruments. The target population of the initial survey was all farmers grossing over \$10,000 in the Lamoille and Missiquoi watersheds in Vermont. The Lamoille watershed was selected because the land use distribution there is representative of the land use distribution in Vermont. The Missiquoi watershed was included to expand the coverage area and enable the aggregation of survey results with previous studies. The survey was designed by a transdisciplinary research team and data collected included farm characteristics, farmer demographics, on-farm presence of best management practices, use of conservation programs, and farmer perceptions of climate change. The USDA National Agricultural Statistics Service (NASS) conducted the survey, identifying farmers in each watershed using zip codes. Due to the imperfect alignment of zip codes and ecological boundaries, some of the sampled farms may not lie within the watersheds; responses from these farmers were included in the study as it was decided their location was proximal enough to do so.

A screening postcard was mailed to all eligible farmers in the Lamoille and Missiquoi watersheds ( $N = 1104$ ) in order to determine willingness to participate in the survey. A total of 220 screening postcards were returned, a response rate of 20%, with 114 farmers agreeing to take the full survey. The surveys were mailed in late March 2013 to those farmers as well as postcard respondents who had replied with a maybe or



left that question blank. In total, 128 surveys were sent mailed. A follow-up phone call was placed three weeks later in an attempt to increase the response rate. In late June, phone surveys were conducted with farmers who had not yet responded on paper. The total number of completed surveys received was 79, a response rate of 62% for the subpopulation of postcard respondents but only a 6.5% response rate for the farmer population in the two watersheds.

Due to the lower than anticipated  $n$  and the higher than anticipated item non-response for the key question in this project, additional data was collected the following winter by adding questions to a survey focused on conservation practices. The target population of that survey was Vermont farmers grossing over \$1000 and participants were recruited using convenience sampling. The instrument included structured and open-ended short answer questions designed to collect demographic data as well as information about conservation practices and conservation programs. Surveys were conducted in-person at an agricultural conference ( $n=11$ ), at a farmer interest group meeting ( $n=6$ ), and on-line using Lime Survey ( $n=44$ ) generating a total of 61 completed surveys. The survey link was distributed through technical service providers' agricultural listservs and newsletters as well as through a Vermont Agency of Agriculture listserv. An incentive was offered in exchange for participation. The distribution channels selected and utilized ensured that primarily farmers, not homesteaders or gardeners considered to have a farm under the census definition, could choose to complete this survey.

#### **4.1.2 Demographic Analysis**

Results from both surveys were combined and the demographic characteristics compared to ensure that no farmer had taken both surveys. All data analysis was performed using SPSS and included frequencies, descriptive statistics, Chi<sup>2</sup> crosstabs, and independent sample T-tests. Differences were checked for between the following five different respondent groupings: those who responded by mail compared to those who responded by phone to the first survey, respondents to the first compared to the second survey, and those who responded to the conjoint question compared to those who did not for all respondents combined and grouped by survey. In all of the analyses, the decision was made to classify all certified organic farmers and those who farm organically but are not certified together under organic. This combination made sense because those two groups tend to employ similar agricultural practices.

#### **4.1.3 Conjoint Analysis**

In their literature review of 84 conjoint analysis papers, Alrikkson & Oberg (2008) note the increasing use of conjoint methods in environmentally-related applications and identify opportunities for future research in environmental fields. Of the papers reviewed, only two focused on agriculture. This research is an application of conjoint analysis in the agricultural field. The preferences and WTA of Vermont farmers for three different best management practices are examined. A full profile rank order response mode with a part-worth conjoint model was used. The following section outlines the conjoint question design and data analysis methods used for this project.

#### 4.1.4 Question Design

The three best management practices selected to be used in this study were cover cropping, conservation tillage, and conservation buffer strips. Each can be used on a variety of farm types, has the potential to improve environmental health, increase the resiliency of farm systems, and were confirmed by UVM Extension staff as being widely used in Vermont. These characteristics fulfill Hanley et al.'s (2001) and Blamey et al.'s (2002) criteria for attribute selection. Each attribute selected was supply-relevant, policy-relevant, measurable, and applicable to a variety of farm types; this tends to increase the external applicability of the results (Alriksson & Öberg, 2008; Blamey et al., 2002; Hanley et al., 2001). Next, each practice and combination of practices was assigned a price according to the results of a literature review and input from UVM Extension staff; the assigned price served as a signal of the level of incentive payment offered to farmers in the survey question. Premiums of 30% were calculated and randomly assigned to three of the seven attribute combinations. The addition of premiums reflects the recommended conjoint method of using prices that are equal or slightly greater than the current market price (Green & Srinivasan, 1978). Practice attributes were either present or absent in each scenario. Price either had a premium or no premium included. Including price, there were four different attributes, each with 2 levels, resulting in  $2^4 = 16$  possible combinations of conservation practice alternatives.

To avoid respondent fatigue and cognitive difficulties, an orthogonal array was constructed and used to reduce the number of alternatives presented in the question from sixteen to seven. The alternatives were removed under the assumption that those

combinations of attributes would never be selected by respondents as other alternatives would always provide higher levels of utility (Green & Srinivasan, 1978). Survey recipients were then asked to rank these seven alternatives from 1-7. A rank of one indicated that the alternative was the most preferred option. A rank of seven indicated that it was the least preferred option. Descriptions of each practice were included in the appendix of the survey for reference by respondents if needed. If the ranking task was completed, it follows that each respondent generated seven observations. Table 1 presents the seven different options offered to farmer respondents.

**Table 1: Combinations of conservation practices offered in conjoint question**

Option	Price	Practices
1	30	Conservation tillage
2	90*	Cover cropping
3	105	Conservation buffer strips
4	120*	Conservation tillage and cover cropping
5	170*	Conservation tillage and conservation buffer strips
6	175	Cover cropping and conservation buffer strips
7	205	Cover cropping, conservation tillage, and conservation buffer strips

*Note:* \* prices have a 30% price premium attached

#### **4.1.5 Conjoint Question Response**

Data for the conjoint analysis was collected through two different surveys. The initial survey had a total of 79 respondents, 55 of whom provided answers to the conjoint

question. Of these, 30 completed their ranking task fully while 25 provided responses which were incomplete or included a double rank. These observations were sorted individually according to criteria established by the authors resulting in 8 respondents and a total of 103 observations deemed invalid and removed. The second survey with which conjoint data was collected had a total of 61 respondents, although 11 were not given surveys that included the conjoint question due to situational restraints. There were 38 respondents who provided answers to the conjoint question. Of these, 33 completed their ranking task fully while 5 provided responses which were incomplete or included a double rank and were subsequently sorted using the criteria used with the first survey. This resulted in the removal of 24 observations. The total number of observations used in this analysis is 524, representing 85 different respondents.

#### **4.1.6 Preference Model and Variable Coding**

The contingent ranking response mode used in this study can be expressed by the following preference model.

$$R = f(X_1, X_2, X_3, X_4)$$

Here,  $R$  is the rank given to each alternative scenario which is a function of the components of each alternative.  $X_1$  represents price,  $X_2$  is the implementation of cover cropping,  $X_3$  is the implementation of conservation tillage, and  $X_4$  is the implementation of conservation buffers. The attribute levels and variable coding are presented in Table 2 below.

**Table 2: Attribute names, levels, and variable types**

Attribute Name	Attribute Levels	Variable Type
Cover cropping ( $X_2$ )	Implemented	Dummy
	Not implemented	
Conservation tillage ( $X_3$ )	Implemented	Dummy
	Not implemented	
Conservation Buffer Strips ( $X_4$ )	Implemented	Dummy
	Not implemented	
Payment per Acre ( $X_1$ )	\$30	Linear
	\$90	
	\$105	
	\$120	
	\$170	
	\$175	
	\$205	

#### 4.1.7 Weighting of Observations

In order to compensate for the fact that some rankings included in the analysis were fully complete while others were not, a weighting scheme was designed. The purpose of the weighting scheme was to ensure that the respondents who clearly understood the task and fully completed it had the appropriate degree of representation in the results. Each observation that was part of a completed ranking scheme received a

direct weight of 1, or 7/7 observed and non-duplicated ranks. The weight of observations that were part of an incomplete ranking was dependent on the number of issues in the ranking scheme. For example, if there was one double rank issued but all alternatives received a rank, the assigned weight to each of those observations was 6/7. If only five alternatives received a rank from the respondent, each of those observations received a 5/7. As the sum of the weights should equal the sample size, the direct weights were then adjusted using the following equation where  $W_i$  is the adjusted weight for the  $i^{th}$  individual and  $N$  is the sample size.

$$\sum_{i=1}^N \frac{W_i}{N} = 1$$

The adjusted weights for each respondent were then used in the WLS regression model to calculate the part-worth utilities of the attributes. The frequencies of the adjusted weights used in the data analysis are presented in Table 3 below.

**Table 3: Frequencies of Weights**

Direct Weight	Adjusted Weight	Frequency	Percent
.143	.170	10	11.76
.286	.341	1	1.18
.429	.511	2	2.35
.571	.681	5	5.88
.714	.852	2	2.35
.857	1.022	4	4.71
1.000	1.192	61	71.76

#### 4.1.8 Weighted Least Squares Regression

Using the weighting scheme described above, a WLS regression was run to calculate the coefficients of each attribute for use in determining the part-worth of each. The regression model used is:

$$R_{ij} = \beta_0 + X_1\beta_1 + X_2\beta_2 + X_3\beta_3 + X_4\beta_4 + e_{ij}$$

where  $R_{ij}$  represents the rank of the  $i^{th}$  respondent for the  $j^{th}$  option. Alternatives are represented as follows:  $X_1$  is the continuous variable for price,  $X_2$  is the dummy variable for cover crops,  $X_3$  is the dummy variable for conservation tillage, and  $X_4$  is the dummy variable for conservation buffer strips. Each coefficient ( $\beta_1$ -  $\beta_4$ ) will be estimated using this WLS model.  $e_{ij}$  is the error term of the  $i^{th}$  respondent for the  $j^{th}$  option. T-statistics



will indicate the significance level of each of the coefficients and the adjusted  $R^2$  value will indicate how well the model explains the variability of the dependent variable (rank).

#### **4.1.9 Part-worth Utilities**

The coefficients from the WLS model are used to calculate the part-worth utility of each attribute. The part-worths indicate how influential each attribute is when the respondent is ranking their preferences. Part-worths of each attribute were calculated by multiplying the coefficients by the variable value of each level. In this case, because respondents are indicating preference according to WTA, the calculated part-worths are indicative of how hard it would be for the farmer to implement the specific practice in their current farm system. For example, a large negative coefficient indicates that the practice is difficult for farmers to integrate into their current management system.

#### **4.1.10 Relative Importance**

Though there has been some debate in the literature as to whether rank-order conjoint allows for a comparison of the relative importance of each attribute in determining respondent choice, many contingent ranking studies apply this technique (see van der Meulen et al., 1996 and Conner & Mabaya, 2006 for examples). The calculation of relative importance uses a base of zero to translate part-worth utility values into values that allow for more meaningful comparisons of results. The following equation from Halbrendt et al. (1995) is used to calculate the relative importance of each  $i^{th}$  attribute:

$$RI_i = 100 \times \frac{UR_i}{\sum UR_j} \quad (\text{and } \sum RI_i = 100)$$

Here,  $UR_i$  is the difference between the highest and lowest part-worth values for the  $i^{th}$  attribute and  $\sum UR_j$  is the sum of the ranges of all the attributes. The relative importance of each attribute is reported as a percent so the sum of the relative importances of each attribute should be 100.

#### 4.1.11 Estimation of Willingness-to-Accept

Attribute part-worths can be used to calculate respondents' willingness-to-accept (WTA) for each attribute of the scenarios presented. To generate respondents' WTA, the Compensation Equivalent Index (CEI) must first be calculated for each attribute. This is the WTA version of the Expenditure Equivalent Index typically used to calculate respondents' willingness-to-pay amounts (Payson, 1994). The CEI indicates the change in incentive payment necessary for a farmer to be indifferent between the baseline option and other alternate scenarios. The following equation from Payson (1994) was used to calculate the CEI.

$$CEI = 1 - \frac{\sum_{i=1}^k B_i dc_i}{yP}$$

Here,  $B_i$  is the estimated coefficient for the  $i^{th}$  attribute,  $dc_i$  is the change in the  $i^{th}$  attribute level,  $y$  is the estimated coefficient for price, and  $P$  is the price of the baseline option. As the conjoint survey question did not include a baseline, or status quo, option, the intercept

(4.994) was used to calculate the CEI. The intercept from the WLS regression model represents a situation in which none of the three BMPs are implemented and the farmer still receives a baseline payment of \$4.99/acre.

From the CEI results, farmers' WTA for each attribute can be determined. In this case, the WTA indicates the level of incentive payment desired by farmers to implement each of the three best management practices. Applying the additive property of part-worths, the WTA for alternatives consisting of combinations of BMPs was also calculated. WTA results are presented as total dollar amounts. A comparison is made between the calculated WTA, the mean cost-share per acre available through EQIP, the mean stated cost per acre by respondents to the second survey, and mean cost per acre found in the literature.

#### **4.1.12 Additional Data Analysis**

Three other methods of data analysis were implemented in an attempt to enrich the results of the conjoint analysis. First, a multinomial logistic regression model was designed. MNL models in conjoint are based on Random Utility Theory and take the form similar to that found in Blamey et al. (2002).

$$U_{ij} = V_{ij}(X_{ij}, S_i) + u_{ij}$$

Here,  $U_{ij}$  is the utility level obtained by the  $i^{th}$  respondent from the  $j^{th}$  alternative product or scenario. In other words, the utility obtained by respondents from alternative scenarios is not only a function of the attributes to them ( $X_{ij}$ ) but also of their demographic and

farm characteristics ( $S_i$ ). The premise of Random Utility Theory works off of the assumption that respondents will always select the option that gives them the greatest level of utility. Two MNL models were constructed using the least frequently selected top choice and last choice of respondents as the reference category. However, due to the fact that a low initial  $n$  necessitated conjoint data being collected in the second survey which yielded demographic data less robust than that generated by the first survey, no demographic variables emerged as significant in the MNL regression analysis.

The second and third supplemental forms of data analysis were attempts to increase the adjusted  $R^2$  value of the WLS regression model. First, demographic variables were added to the model as explanatory variables. No variables were significant indicators of assigned rank. The reason for this is likely the same issue with robustness of demographic variables for all respondents discussed above. Next, the sample was split approximately in half into dairy farmers (37) and all other farmers (48) and the WLS regression analysis was performed. Based on the fact that preferences tend to be more uniform among respondents with similar demographic characteristics, this had the potential to increase the explanatory power of the model and provide more useful information regarding farmer WTA incentive levels. No variables were significant indicators of assigned rank. This is likely due to the small sample size in each group as well as the fact that the group of all other farmers was not homogenous.

## **4.2 Article 2 Methods**

### **4.2.1 Data Collection**

A survey of Vermont farmers was conducted beginning in late February 2013. The instrument included structured and open-ended short answer questions designed to collect demographic data as well as information about conservation practices and conservation programs. Surveys were piloted by a small group of farmers and technical service providers. Surveys were then conducted in-person at an agricultural conference (n=11), at a farmer interest group meeting (n=6) and on-line using Lime Survey (n=44). The survey link was distributed through technical service providers' agricultural listservs and newsletters as well as through a Vermont Agency of Agriculture listserv. An incentive was offered in exchange for participation.

All Vermont farmers with a gross farm income of at least \$1000 were eligible to respond. This low threshold level was adopted to allow for representation of beginning farmers in survey responses while the distribution channels selected ensured that primarily farmers, not homesteaders or gardeners considered to have a farm under the census definition, could choose to complete this survey. The total number of responses received was lower than anticipated by the authors (n=61). Reasons for this may include, but are not limited to, a lack of survey sponsorship or organizational affiliation, lack of a sampling frame, the high number of surveys Vermont farmers are asked to participate in during the winter. As a result, the authors are regarding this survey as exploratory research which serves to gather previously undocumented information and inform future projects and policies.

#### **4.2.2 Demographic Analysis**

To analyze the data from the structured questions, SPSS was used to calculate descriptive statistics and run frequencies, Chi<sup>2</sup> crosstabs, independent sample t-test, and binary logistic regression. The open-ended questions were coded and grouped and the frequencies of each response are reported. Using both the quantitative and qualitative data, differences between respondents who had participated in EQIP compared to those who had never participated were explored. For comparison, supplemental EQIP statistics were calculated from an NRCS contract database which spanned from January 1996-May 2013. Dollar amounts were adjusted for inflation and are reported in 2013 dollars.

#### **4.3 NRCS Data**

The contract data from NRCS was sent by an NRCS staff member to the author in May 2013. The data contained all Vermont EQIP contract information from January 1996-May 2013. Contract information was sorted to enable the contract data for each of the three BMPs in the conjoint question to be extracted. Information about project monitoring was also extracted. Practice groups were sorted into active and complete or canceled and deleted. Practice obligations were adjusted to 2013 currency and a mean incentive payment per acre was calculated for EQIP 1996, EQIP 2002, and EQIP 2008.

## **CHAPTER 5: ARTICLE 1**

### *Farmer Adoption of Best Management Practices Using Incentivized Conservation Programs: Calculating Vermont Farmer WTA Incentive Levels Using Conjoint Analysis*

#### **5.1 Introduction**

##### **5.1.1. Background**

The environmental degradation and negative externalities imposed on society by US agricultural production systems have been steadily increasing since the end of World War II (UNCTAD, 2013). These impacts include soil erosion, pollution of waterways and groundwater, greenhouse gas emissions, loss of biodiversity, shrinking wildlife habitat, and pesticide and fertilizer run-off and leaching (Grossman, 2011). Current trends in population growth and demand for food continue to fuel the production of these externalities (UNCTAD, 2013). Climate change and variability will further compound the effects of these challenges to the long-term sustainability of agricultural systems (Walthall et al., 2013). The need to ensure the resiliency and viability of our farms and food systems is a pressing and increasingly salient issue.

The USDA and other agricultural technical service providers emphasize the need for farmers to adopt best management practices (BMPs) to address environmental health concerns, ensure the long-term sustainability of their operations, and to use as an adaptation strategy for coping with climate change (Walthall et al., 2013). A BMP is defined by the USDA as “established soil conservation practices that also provide water quality benefits (Gold, 2007).” Federal conservation programs offer incentive payments which cost-share the implementation of BMPs with farmers. In order for these programs

to be effective, incentive levels must match farmers' financial needs. This study uses conjoint analysis to determine the preferences and willingness-to-accept (WTA) incentive levels for three common BMPs of farmers in Vermont. Results have the potential to predict regional farmer decision-making and preferences for conservation practices and further inform the design of voluntary conservation programs that assist farmers in improving the health of their land and the resiliency of their operations (Green & Srinivasan, 1990; Horne, 2006; J. L. Louviere, 1988).

### **5.1.2 Incentivizing BMP Adoption**

Economics governs farmers' decisions to adopt BMPs more than any other factor (Howden et al., 2007; Wall & Smit, 2005). The practice needs to be profitable and the perceived threats to the viability of the system high enough in order for widespread adoption to occur (Camboni & Napier, 1993; Marra, Pannell, & Ghadim, 2003; Saltiel, Bauder, & Palakovich, 1994; Webb, 2004). An adopted practice is considered profitable when the benefits produced outweigh both the direct costs and opportunity costs of implementation (Mendelsohn, 2000; Pannell, 1999). However, analysis of BMP profitability is not always straightforward; the private benefits of implementation may only be tangible in the medium or long term while the costs are accrued in the short term (Bradshaw et al., 2004; Pannell, 1999; Risbey et al., 1999). In addition, implementation of BMPs creates positive externalities in the form of ecosystem services; if the costs of implementation are greater than the private benefits produced, farmers are privately funding public goods (Kroeger & Casey, 2007; Lichtenberg & Smith-Ramirez, 2011). As public goods are non-rival and non-excludable, if farmers do not perceive enough of a



threat to their farm systems to warrant adoption, they will be better off financially not implementing a BMP regardless of any existing environmental concerns; this lack of proactive adoption can result in the underproduction of ecosystem services and is detrimental to both the farm operation and society (Cary & Wilkinson, 1997; Kroeger & Casey, 2007; E. Lichtenberg & Smith-Ramirez, 2011).

Federal conservation programs are one way to overcome farmers' economic barriers to adoption of conservation practices, counteract the underproduction of public goods, and encourage the prosperity of agricultural systems without sacrificing environmental health (Lichtenberg & Smith-Ramirez, 2011; Smith, 2006). These programs incentivize the supply of conservation practices by cost-sharing up to 75% of the implementation expenses. Payments are designed to compensate farmers for the direct costs incurred and provide a risk premium to offset the uncertainty associated with adoption (Cooper & Signorello, 2008; Kurkalova et al., 2006). However, it is challenging to set incentive levels that are cost-effective for both farmers and the federal government; determining accurate figures for farmers' willingness-to-accept (WTA) for implementing conservation practices that generate ecosystem services is a key step in designing effective public policy and one that needs a continued regional research focus (Claassen et al., 2008; Cooper & Signorello, 2008; Wossink & Swinton, 2007).

This study provides that regional focus by determining the incentive levels desired by Vermont farmers for implementing three common best management practices. Conjoint analysis is used to examine the preferences and WTA incentive levels of Vermont farmers for implementing conservation tillage, cover cropping, and

conservation buffer strips. Calculated WTA figures are compared to historical EQIP cost-share payments for these BMPs. In addition, the relative importance of each attribute in farmer decision-making will be evaluated. A full-profile rank-order response mode with a part-worth conjoint model was designed. Alternatives simulated options farmers actually have available to them when considering which BMPs to implement and whether the conservation incentives offered by the USDA meet their needs.

## **5.2 Methods**

### **5.2.1 Data Collection**

Data for this project was collected using two different survey instruments. The target population of the initial survey was all farmers grossing over \$10,000 in the Lamoille and Missiquoi watersheds in Vermont. The Lamoille watershed was selected because the land use distribution there is representative of the land use distribution in Vermont. The Missiquoi watershed was included to expand the coverage area and enable the aggregation of survey results with previous studies. The survey was designed by a transdisciplinary research team and data collected included farm characteristics, farmer demographics, on-farm presence of best management practices, use of conservation programs, and farmer perceptions of climate change. The USDA National Agricultural Statistics Service (NASS) conducted the survey, identifying farmers in each watershed using zip codes. Due to the imperfect alignment of zip codes and ecological boundaries, some of the sampled farms may not lie within the watersheds; responses from these

farmers were included in the study as it was decided their location was proximal enough to do so.

A screening postcard was mailed to all eligible farmers in the Lamoille and Missiquoi watersheds ( $N = 1104$ ) in order to determine willingness to participate in the survey. A total of 220 screening postcards were returned, a response rate of 20%, with 114 farmers agreeing to take the full survey. The surveys were mailed in late March 2013 to those farmers as well as postcard respondents who had replied with a maybe or left that question blank. In total, 128 surveys were sent mailed. A follow-up phone call was placed three weeks later in an attempt to increase the response rate. In late June, phone surveys were conducted with farmers who had not yet responded on paper. The total number of completed surveys received was 79, a response rate of 62% for the subpopulation of postcard respondents but only a 6.5% response rate for the farmer population in the two watersheds.

Due to the lower than anticipated  $n$  and the higher than anticipated item non-response for the key question in this project, additional data was collected the following winter by adding questions to a survey focused on conservation practices. The target population of that survey was Vermont farmers grossing over \$1000 and participants were recruited using convenience sampling. The instrument included structured and open-ended short answer questions designed to collect demographic data as well as information about conservation practices and conservation programs. Surveys were conducted in-person at an agricultural conference ( $n=11$ ), at a farmer interest group meeting ( $n=6$ ) and on-line using Lime Survey ( $n=44$ ) generating a total of 61 completed

surveys. The survey link was distributed through technical service providers' agricultural listservs and newsletters as well as through a Vermont Agency of Agriculture listserv. An incentive was offered in exchange for participation. The distribution channels selected and utilized ensured that primarily farmers, not homesteaders or gardeners considered to have a farm under the census definition, could choose to complete this survey.

### **5.2.2 Demographic Analysis**

Results from both surveys were combined and the demographic characteristics compared to ensure that no farmer had taken both surveys. All data analysis was performed using SPSS and included frequencies, descriptive statistics, Chi<sup>2</sup> crosstabs, and Independent Sample T-tests. Differences were checked for between the following five different respondent groupings: those who responded by mail compared to those who responded by phone to the first survey, respondents to the first compared to the second survey, and those who responded to the conjoint question compared to those who did not for all respondents combined and grouped by survey. In all of the analyses, the decision was made to classify all certified organic farmers and those who farm organically but are not certified together under organic. This combination made sense because those two groups tend to employ similar agricultural practices.

### **5.2.3 Conjoint Question Design**

This study utilizes conjoint analysis to determine the preferences and WTA incentive levels of Vermont farmers for three different BMPs. A full profile rank order

response mode with a part-worth conjoint model was used. The three BMPs selected for this study were cover cropping, conservation tillage, and conservation buffer strips. Each can be used on a variety of farm types, has the potential to increase the resiliency of farm systems, and were confirmed by UVM Extension staff as being widely used in Vermont. These characteristics fulfill Hanley et al.'s (2001) and Blamey et al.'s (2002) criteria for attribute selection. Each attribute selected was supply-relevant, policy-relevant, measurable, and applicable to a variety of farm types; this tends to increase the external applicability of the results (Alriksson & Öberg, 2008; Blamey et al., 2002; Hanley et al., 2001).

Next, each practice and combination of practices was assigned a price according to the results of a literature review and input from UVM Extension staff. The assigned price served as a signal of the level of incentive payment offered to farmers in the survey question. Premiums of 30% were calculated and randomly assigned to three of the seven attribute combinations. The addition of premiums reflects the recommended conjoint method of using prices that are equal or slightly greater than the current market price (Green & Srinivasan, 1978). In each scenario, practice attributes were either present or absent. Price either had a premium or no premium included. There were four different attributes, each with two levels, resulting in  $2^4 = 16$  possible combinations of conservation practice alternatives.

To enhance the quality of the results by avoiding respondent fatigue and cognitive difficulty, an orthogonal array was constructed and used to reduce the number of alternatives presented in the question from sixteen to seven (Green & Srinivasan,

1978, 1990). The alternatives were removed under the assumption that those combinations of attributes would never be selected by respondents as other alternatives would always provide higher levels of utility (Green & Srinivasan, 1978). Survey recipients were then asked to rank these seven alternatives from 1-7 with a rank of one indicating that the alternative was the most preferred option. Descriptions of each practice were included for reference by respondents if needed. It follows that if a ranking task was completed, each respondent generated seven observations.

#### **5.2.4 Conjoint Analysis**

The initial survey had a total of 79 respondents, 55 of whom provided answers to the conjoint question. Of these, 30 completed their ranking task fully while 25 provided responses which were incomplete or included a double rank. These observations were sorted individually according to criteria established by the authors resulting in 8 respondents and a total of 103 observations deemed invalid and removed. The second survey with which conjoint data was collected had a total of 61 respondents, although 11 were not given surveys that included the conjoint question due to situational restraints. There were 38 respondents who provided answers to the conjoint question. Of these, 33 completed their ranking task fully while 5 provided responses which were incomplete or included a double rank and were subsequently sorted using the criteria used with the first survey. This resulted in the removal of 24 observations. The total number of observations used in this analysis is 524, representing 85 different respondents.

Next a weighting scheme, on a scale from 0 to 1 (or 0/7 to 7/7) was developed to ensure that the respondents who clearly understood the task and had fully completed it

had greater representation in the results than those who only provide partial rankings. The assigned weights were then used to construct a WLS regression model to obtain the coefficients of each attribute. The regression model used was:

$$R_{ij} = \beta_0 + X_1\beta_1 + X_2\beta_2 + X_3\beta_3 + X_4\beta_4 + e_{ij}$$

The part-worths of each attribute were calculated by multiplying the coefficients by the variable value of each level. These part-worths were then used to calculate the relative importance of each  $i^{th}$  attribute using the equation below from (Halbrendt et al., 1995). The relative importance of each attribute is reported as a percent so the sum of the relative importances of each attribute should be 100.

$$RI_i = 100 \times \frac{UR_i}{\sum UR_j} \quad (\text{and } \sum RI_i = 100)$$

Attribute part-worths can be used to calculate respondents' willingness-to-accept (WTA) for each attribute of the scenarios presented. To generate respondents' WTA, the Compensation Equivalent Index (CEI) must first be calculated for each attribute. This is the WTA version of the Expenditure Equivalent Index (EEI) typically used to calculate respondents' willingness-to-pay amounts (Payson, 1994). The CEI indicates the change in incentive necessary for a farmer to be indifferent between the baseline option and other alternate scenarios. The following equation from Payson (1994) was used to calculate the CEI.

$$CEI = 1 - \frac{\sum_{i=1}^k B_i dc_i}{y^P}$$

As the conjoint survey question did not include a baseline, or status quo, option, the intercept (4.994) needed to be used to calculate the CEI. The intercept from the WLS regression model indicates that if none of the three BMPs are implemented, the farmer still receives a baseline price of \$4.99/acre.

From the CEI results, farmers' WTA for each attribute can be determined. In this case, the WTA indicates the level of incentive payment desired by farmers to implement each of the three best management practices. Applying the additive property of part-worths, the WTA for alternatives consisting of combinations of BMPs was also calculated. WTA results are presented as total dollar amounts. A comparison is made between the calculated WTA, the mean cost-share per acre available through EQIP, the mean stated cost per acre by respondents to the second survey, and mean cost per acre found in the literature.

## 5.3 Results

### 5.3.1 Summary Statistics

The total number of survey respondents was 140, with 79 farmers responding to survey one and 61 responding to survey two. However, only 85 respondents answered the conjoint analysis question and therefore that was the sample size used for the majority of this analysis. The summary statistics, grouped by survey, for the conjoint respondents are presented in Table 4.



**Table 4: Demographic Characteristics of Conjoint Respondents by Survey Group**

Variable	Survey 1 (n=47)		Survey 2 (n=38)	
Mean Farm Size (Acres)	248.45		285.49	
Number of Years Farming	30.61		-----	
Age of Farmer	64-75 years		-----	
	Frequency	Percent	Frequency	Percent
<b>Main Products Sold</b>				
(% of farms with product $\geq$ 50% of sales)				
Fluid Milk	15	31.9	21	56.8
Meat	7	14.9	7	18.9
Vegetables	7	14.9	2	5.4
Hay and/or crops for animal consumption	7	14.9	4	10.8
Value-added products	2	4.3	0	0
<b>Market Outlets</b>				
(% of farms with market $\geq$ 50% of sales)				
Wholesale	-----	-----	21	55.7
Farmers' markets or farmstand	-----	-----	11	29.5
CSA	-----	-----	5	14.8
Other	-----	-----	1	2.6
Land certified organic (% of farms)	27	57.4	19	51.4
Animals certified organic (% of farms)	-----	-----	11	28.9

**Table 4 - continued**

Variable	Survey 1 (n=47)		Survey 2 (n=38)	
	Frequency	Percent	Frequency	Percent
Gross Sales (\$10,000-24,000)	16	20.3%	-----	-----
Mean Household Income from Farm (%)	-----	52.75	-----	62.78

The low response rate of the initial survey necessitated collecting more conjoint observations through another survey and much of the demographic information collected on survey one was not collected on survey two. The length of the second survey accounts for the generation of this discrepancy; the authors were attempting to keep the length of survey two at five minutes and this required limiting the collection of demographic information. Table 5 presents the totals for the demographic variables that did overlap in both surveys while Table 6 presents the adoption trends for the three BMPs included in the conjoint questions as well as respondent rates of participation in EQIP.

**Table 5: Demographic Characteristics of Conjoint Respondents (n=85)**

Variable		
Mean Farm Size (Acres)	279.22	-----
	Frequency	Percent
Products Sold		
(% of farms with product $\geq$ 50% of sales)		
Fluid Milk	37	43.5
Meat	14	16.5
Vegetables	9	10.6
Hay and/or crops for animal consumption	11	12.9
Value-added products	2	2.4
Land certified organic (%)	46	54.1
Household Income from Farm (%)	-----	56.99

**Table 6: Respondents' Use of Conservation Practices & EQIP (n=85)**

	Frequency	Percent
Practice		
Cover cropping	35	41.2
Conservation tillage	18	21.2
Conservation buffer strips	24	28.2
Enrolled in EQIP	38	44.7

Examination of these summary statistics using Chi<sup>2</sup> crosstabs and t-tests determined that some significant differences do exist between some of the five possible paired groupings of respondents. The comparison of phone and mail respondents was the only pairing for which no differences existed. When the respondents of each survey were compared, those who took survey two were significantly more likely to have had an EQIP contract (.000). Next, conjoint respondents and non-respondents were compared for survey one, survey two, and all respondents. Between the two groups in survey one conjoint respondents were significantly more likely to have implemented cover crops (.020). Interestingly enough, there were no significant differences in conjoint respondents' and non-respondents' views on the increasing frequency of extreme weather events or their attitudes towards climate change. Among survey two respondents, those who answered the conjoint question were more likely to be primarily dairy farmers (.013) and, at a 90% confidence level, more likely to have implemented cover crops (.098). When all respondents were examined together, conjoint respondents were more likely to be primarily dairy farmers (.016), have had an EQIP contract (.046), and have implemented cover crops (.007) and conservation buffer strips (.091 at .100 significance level).

Finally, the demographic information of the survey respondents is compared to the demographic information of Vermont farmers collected in the 2012 Census of Agriculture in Table 7. Though the low *n* and methods of analysis used in this study did not allow for the use of population weights, it is interesting to note that the mean farm

size of respondents' is larger than the state average and that dairy farmers and certified organic growers were oversampled.

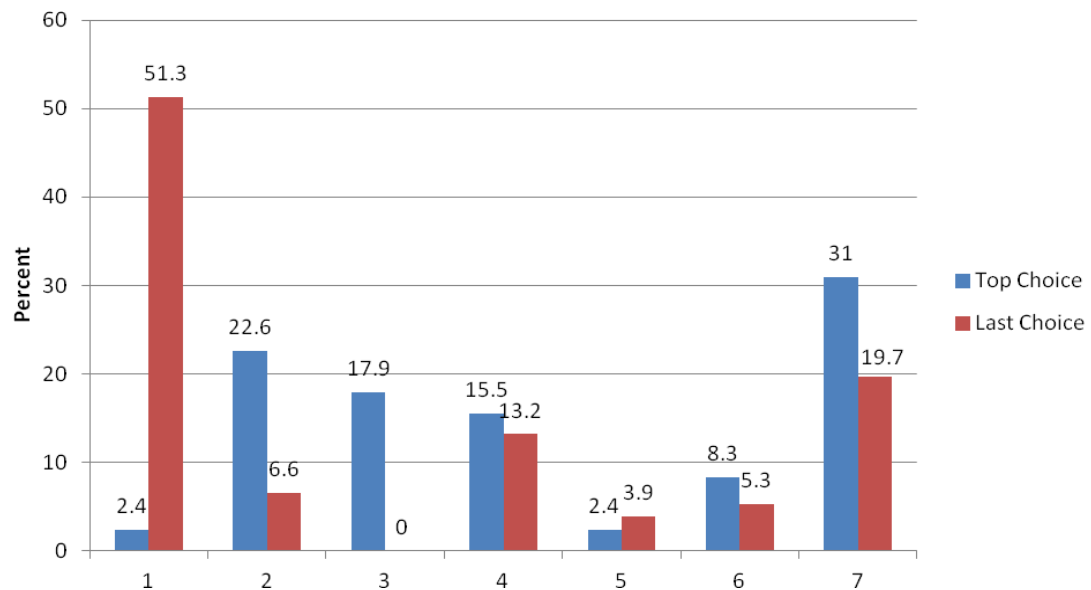
**Table 7: Comparison of Survey Respondents with Vermont Farmer Population**

Variable	Survey Respondents		Vermont Farmers	
Mean Farm Size (Acres)	279.22		171	
	Frequency	Percent	Frequency	Percent
Products Sold				
(% of farms with product $\geq$ 50% of sales)				
Fluid Milk	37	43.5	934	12.7
Meat	14	16.5	-----	-----
Vegetables	9	10.6	814	11.1
Hay and/or crops for animal consumption	11	12.9	3396	46.3
Value-added products	2	2.4	-----	-----
Land certified organic (%)	46	54.1	513	7.0

### 5.3.2 Conjoint Analysis

The most preferred conjoint option presented to respondents was the offer of \$205 per acre to implement cover crops, conservation tillage, and conservation buffer strips. The least preferred combination was the offer of \$30 per acre to implement

conservation tillage only. The percentage of farmers who chose each option as their first and last choice is presented in Figure 1 below. (See Table 1 for the details of option composition.) The majority of dairy farmers (12/37) and hay and animal feed growers (3/9) selected Option 7 as their top choice while meat producers (4/12) and vegetable farmers (4/7) tended to prefer Option 2 most often.



**Figure 1: Most and Least Preferred Conjoint Options**

The results of the WLS regression model indicated that price (.069) and the inclusion of conservation tillage (.041) are significant influences in farmers' ranking decisions (see Tables 8 and 9). A positive regression coefficient for a practice attribute indicates a high degree of difficulty associated with the implementation of that BMP. The negative coefficient for the incentive attribute indicates a positive influence of price on the choice to implement or not; the higher the incentive payment, the more likely the

option is to be selected as a top choice. It follows that positive part-worths generate less utility for respondents while larger negative part-worths produce the highest amounts of utility.

**Table 8: WLS Regression Results**

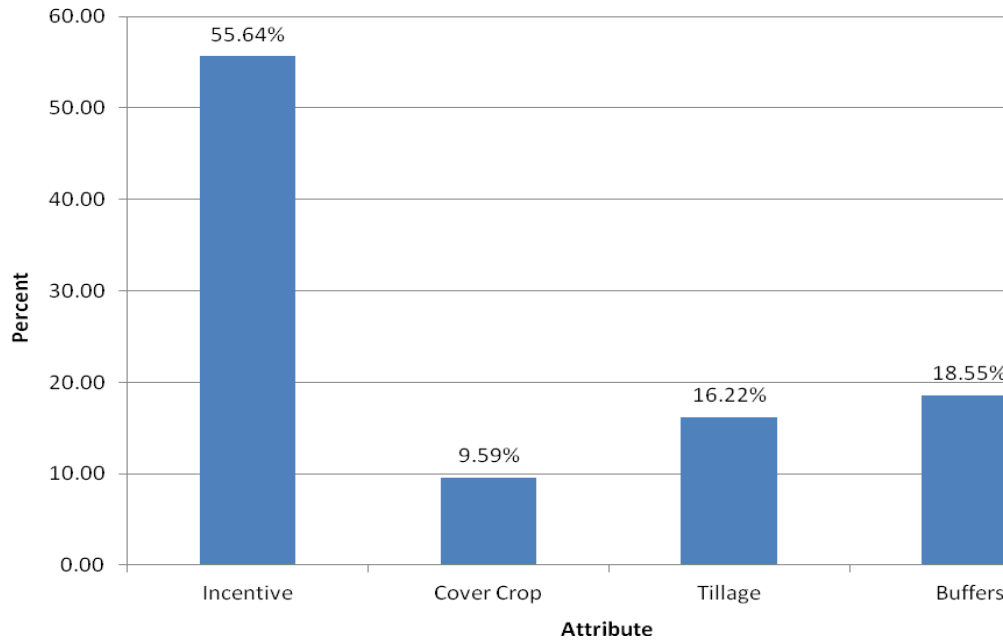
Attribute	Beta	t-value	Significance
Intercept	4.994	21.54	-----
Incentive	-.012	-1.82	.069
Cover Crop	-.362	-.738	.461
Tillage	.612	2.05	.041
Buffers	.700	1.005	.316
F-Statistic	14.959		
R <sup>2</sup>	.103		
Adjusted R <sup>2</sup>	.096		

**Table 9: Attribute Part-Worths**

Attribute	Part-worth
Incentive - \$30	-.36
Incentive - \$90	-1.08
Incentive - \$105	-1.26
Incentive - \$120	-1.44
Incentive - \$170	-2.04
Incentive - \$175	-2.10
Incentive - \$205	-2.16
Cover Crop	-.362
Conservation Tillage	.612
Conservation Buffers	.700

The part-worths were then used to calculate the relative importance of each attribute; this form of conjoint interpretation uses a base of zero and so has more value when making comparative statements about attribute importance (see Figure 2). Incentive level was the attribute with the greatest influence on farmer decision-making. The presence of buffer strips or conservation tillage in a scenario influenced farmers' decisions almost twice as much as the presence of cover cropping.





**Figure 2: Relative Importance of Attributes in Farmer Decision-Making**

Lastly, the WTA incentive levels desired by respondents were calculated using the CEI. The WTA required for Options 4-7 were calculated by summing the calculated WTA levels for each attribute offered in the option. WTA estimates ranged from \$35-118 more than the payments per acre offered in the conjoint question, despite the fact that three of the options had a 30% premium added (see Table 10).

**Table 10: WTA of Farmers for Implementation of Conservation Practices**

Option	Practices	\$/A - Offered	\$/A - WTA
1	Tillage	30	85.99
2	Cover cropping*	90	125.16
3	Buffers	105	168.33
4	Tillage & Cover cropping*	120	211.15
5	Tillage & Buffers*	170	254.32
6	Cover cropping & Buffers	175	293.49
7	Cover cropping, Tillage, & Buffers	205	349.48

Note: \* indicates that a 30% premium was added to incentive offered

The WTA incentive levels were then compared to the implementation cost per acre found in three other data sources (see Table 11). All costs per acre are reported in 2013 dollars. The farmer estimates of cost per acre are from a question on the second survey through which conjoint data was collected. The EQIP contract data is presented in two different forms- as a mean cost-share level for EQIP 2008-2013 and, using the assumption that the mean cost-share covers 75% of expenses, as an estimate of the full cost of implementation. For cover cropping, the WTA level exceeded the mean EQIP cost-share level by \$68. The WTA calculated for conservation tillage was \$38 higher than the mean EQIP cost-share. Respondents' WTA for implementing buffer strips was \$121 lower than the mean cost-share amount paid for contour buffer strips but aligned with the estimated cost per acre for annual grass buffer strips found in the literature.

**Table 11: Comparison of Mean Cost/Acre for 3 BMPs**

Practice	\$/Acre	Source of Estimate
COVER CROPPING	125.16	Conjoint WTA Results
	57.13	EQIP 2008-2013: Cost-share
	76.17	EQIP 2008-2013: Full Cost****
	77.26	Survey 2 – Farmer Estimates
CONSERVATION TILLAGE	85.99	Conjoint WTA Results
	47.85	EQIP 2008-2013: Cost-share
	63.80	EQIP 2008-2013: Full Cost****
	46.94	Survey 2 – Farmer Estimates
No Till, conventional	160.00	Literature Review*
CONSERVATION BUFFERS	168.33	Conjoint WTA Results
	95.00	Survey 2 – Farmer Estimates
Contour Buffer Strips	289.98	EQIP 2008-2013: Cost-share
	386.64	EQIP 2008-2013: Full Cost****
Filter Strips	666.63	EQIP 2008-2013: Cost-share
	888.84	EQIP 2008-2013: Full Cost****
Perennial Grass Buffer Strips	278.57	Literature Review**
Annual Grass Buffer Strips	159.52	Literature Review***

\* Uri, 2000; Rodale, 2011

\*\* Rein, 1999; Tourte et al., 2003b

\*\*\* Nakao et al., 1999; Qiu, 2003; Rein, 1999; Tourte et al., 2003b; Yang & Weersink, 2004

\*\*\*\* Calculation of full cost uses assumption of 75% cost-share levels

## **5.4 Discussion**

### **5.4.1 Data Collection Process**

The first survey was designed by a transdisciplinary research team and conducted by NASS. This research is part of the Vermont Agriculture Resiliency Initiative which is examining agricultural issues that are transdisciplinary in nature; the resulting composition of the research team allows for a systems approach to finding solutions. Implementing the survey through NASS achieved a workable balance between the benefits of in-house time saved and access to a complete sampling frame. The disadvantages of working with NASS included a greater financial commitment and lack of researcher control over the process. Two issues, with the project timeline and survey length, arose from the survey development and implementation processes and directly impacted the survey response rate.

Due to delays caused by the number of people involved in its development, the survey was not mailed at the time of year anticipated. Had the postcards been sent in early November, the surveys could have gone out in early January and farmers would have received the survey in the off-season. Instead, farmers received it just as they were ramping up in the spring when there is a high opportunity cost associated with completing a survey. Adhering to the initial timeline would also have meant that this survey was received before the 2013 Agricultural Census and farmers would likely have been more apt to fill it out. The significant length of the survey, a by-product of ensuring that all team members' questions were included, also likely decreased the response rate

and increased the measurement error due to respondent fatigue. The low number of completed surveys received necessitated the collection of more conjoint data through another shorter survey which collected much less demographic information. This hindered the potential of the data analysis as a more robust application of Random Utility Theory, using multinomial regression models and more complex weighting strategies, was not possible within the constraints of the combined demographic data.

#### **5.4.2 Use of Conjoint Analysis**

The use of conjoint analysis for this study was a choice that proved advantageous in the context of both the survey and the results. After the number of stimuli was reduced using the orthogonal array, the contingent ranking approach enabled the collection of seven observations per person in a relatively short amount of time per respondent. Thus, with one question, the preferences of farmers for the three BMPs and the impact of the incentive payments offered on their decision-making processes were elicited. Using the additive property of part-worths, the four calculated WTA incentive levels can be summed to determine WTA levels for various combinations of those attributes (Green et al., 2001; J. J. Louviere et al., 2000). The choice of the contingent ranking conjoint method proved advantageous as it, unlike contingent rating exercises, forces respondents to choose one alternative over all the others, mimicking real life management decisions. Additionally, because farmer preferences are intricately linked to their specific farm operations, the fact that conjoint analysis is based on the Random Utility Model further validates the methods employed in this study.

Though there were many advantages to using conjoint analysis for this study, some external validity issues do exist. The first issue stems from the fact that certain segments of the Vermont farmer population were oversampled. Large farms, dairy farms, and organic growers participated in the survey at a rate disproportionate to their representation in the population. This point is addressed when future research projects are discussed. The rest of the external validity and reliability issues arose from the authors' specific design and method of analyses selections. Design and analysis factors that may affect the external validity of all conjoint analyses stem from the fact that decisions as to the number and type of attributes included in the study are researcher instead of respondent driven and that the decision-making processes of the respondents are not evident to researchers; thus conjoint analysis requires the assumption that all the information used by respondents to make decisions was included in the alternatives presented, which can never actually be the case (Blamey et al., 2002; Louviere, 1988). This could have been partially remedied in our survey by including clarifying questions that asked respondents to link their rankings with their specific farm businesses (Van der Meulen, De Snoo, & Wossink, 1996). External validity of this conjoint analysis may also have been affected because farm management decisions are not as straightforward as consumers' purchasing decisions. When calculating part-worths, only the main effects of the model are included. Thus, it seems that ignoring interaction effects in this situation may potentially have a greater effect on the predictive validity of these results than in marketing studies. The last potential external validity problem created by using conjoint analysis in this context is that the data collection process did not allow for a direct way to

examine the difference between respondents' stated and revealed preferences.

Comparing the two is a standard approach to check for consistency and quality of responses (Alriksson & Öberg, 2008).

In addition to the predictive validity issues discussed above, our conjoint survey question has four internal validity issues. These are outlined below and are important to note to inform future WTA studies. First, because the presentation of attributes can affect the observations collected, attribute choices should be randomized (Green & Srinivasan, 1978; Hanley et al., 2001). On the NASS survey, the alternatives were listed in ascending price order; on the second survey the list was randomized and the response rate to the conjoint question increased. Next, measurement error may have been created in two different ways. Conjoint studies are considered best administered in person or on paper (Wittink & Cattin, 1989). Due to the low response rate, almost half of the first survey was completed over the phone. This removed the visual aid and practice descriptions provided on the paper version from the presentation of the ranking task and likely affected the results. In addition, whenever there is a task that may prove cognitively difficult for respondents, it is preferable to conduct a test to determine whether answers provided are consistent with their true preferences (Alriksson & Öberg, 2008). Conduction of our survey in mail, on-line, and phone format prevented the inclusion of such a quality check. The last internal validity issue with this conjoint question stems from the fact that a status quo scenario was not included in the set of alternatives to provide a reference point for respondents and a baseline scenario for data analysis (Hanley et al., 2001). The omission of a status quo can create internal validity

issues because respondents are forced to state their preferences based on given alternatives, even if their actual preference would be to maintain status quo (Hanley et al., 2001).

#### **5.4.3 Demographic Analysis**

Using the demographic data collected, different groupings of respondents were compared to determine if any significant difference existed among respondents. When respondents to survey one were compared to those of survey two, the only significant difference was that survey two respondents were more likely to have had an EQIP contract. This is likely because survey two was focused on conservation programs and it is logical that farmers who have had experiences with EQIP and NRCS would be more apt to complete that survey. Next, conjoint respondents were compared to conjoint nonrespondents. Conjoint respondents were more likely to be dairy farmers, have had an EQIP contract, and have implemented BMPs than conjoint non-respondents. This fact may actually serve to increase the external validity of the results; due to the composition of Vermont's agricultural economy, a lot of extension outreach in the state is focused on dairy farmer adoption of BMPs which may explain the frequency with which dairy farmers answered the conjoint question. Following similar reasoning, farmers who have implemented some BMPs and have received financial assistance with implementation through EQIP may be more likely to respond to a question asking them to evaluate trade-offs between incentive packages; critical thinking and strategies about BMP adoption undertaken prior to the survey likely facilitated respondents' straightforward evaluation of conjoint alternatives.



#### **5.4.4 Conjoint Analysis: Big Picture Conclusions**

The results of the conjoint analysis point to three major conclusions. These are outlined below and will be discussed further in the Program and Policy Implications section.

1. The more difficult a practice is to implement, the more its presence affects adoption decisions.
2. The higher the incentive payment offered, the more willing farmers are to adopt BMPs (even those which are difficult to implement).
3. The incentive payments offered in EQIP contracts may be lower than Vermont farmers' preferred incentive levels. This may be affecting the adoption rate of BMPs by Vermont farmers and subsequently impacting the environmental health and resiliency of the state's agricultural systems.

#### **5.4.5 BMP Preferences & Part-worth Utilities**

Respondents' preferences for BMP implementation scenarios were compared with the results of the part-worth calculations and it can be concluded that the preferences align with the meaning of the part-worth utility for each attribute. The offer of \$30 per acre to implement conservation tillage was the last choice of over half the respondents. The part-worth calculated for tillage signifies that it is a difficult practice to successfully integrate into a management system. Indeed, this BMP has a steep learning curve, significant risk, and capital investment associated with implementation, and is the most difficult to make compatible across farm size and types. In addition, the incentive offered in the conjoint question was one-third less than farmers' estimated costs and less than

half of the average EQIP cost-share payment. In contrast, the offer of \$205 per acre to implement all three BMPs was the most preferred by respondents. The part-worth of price indicates that if the financial payment is high enough, farmers will be incentivized to adopt the practices; this is in-line with the research that has demonstrated that economic variables are the most important factors governing farmer decision-making.

If respondents' most preferred BMP implementation scenarios are examined according to their major product sold, results again align logically with farm characteristics and attribute part-worths. Despite being based on a low number of respondents per category, these trends likely have external validity. Dairy and hay/animal feed farmers tended to prefer the highest incentive payment for implementing all three options. This likely reflects the efforts of extension agents to increase the adoption of these BMPs. The larger average size of these farms may also enable more efficient adoption of these practices, thereby increasing the likelihood of adoption. Meat producers most often preferred to be paid for implementing cover crops and establishing buffer strips. It can be inferred that meat producers might utilize cover cropped fields as pastures and that buffer strips fit logically into grazing plans. Because many Vermont farmers have diversified operations, it is possible that many of the meat farmers who responded are also raising vegetables and cover cropping those fields. The majority of vegetable farmers also preferred the cover crop only option; this is logical as it is the practice most utilized by, and which most directly benefits, vegetable farms. The part-worth of cover cropping indicates that it is not a difficult practice to implement and it has low implementation costs.

#### **5.4.6 Relative Importance of Attributes**

The attribute with the most influence on farmers' decisions is the incentive level offered; as farmers ranked the scenarios presented to them, the relative importance of the incentive amount was 55.6%. This further supports the finding in the literature that the variable with the greatest influence on farmer adoption decisions is the effect that the adoption of a BMP will have on their economic bottom line. Tillage and buffers had the next highest levels of relative influence on farmer decisions. This reflects the amount of time, initial capital investment involved, and high short-term costs leading to benefits accrued predominantly in the long term when implementing those BMPs. The presence of cover crops in a scenario had the least relative importance in farmers' adoption decisions. This is logical as cover crops are highly adaptable to different farm scales, trialable, fairly inexpensive, and can generate observable on-farm benefits rapidly.

#### **5.4.7 WTA Incentive Levels**

The calculated WTA incentive levels are on the higher end of the mean cost per acre range for each of the three BMPs but all are reasonable estimates. Though evidence points to the external validity of the WTA results, in this section three topics will be discussed to bring to light important points to keep in mind about the calculated WTA values. The first topic addressed deals with the comparability of the calculated WTA for buffer strips. This is followed by a discussion of factors which could have an impact on the external validity of the results that can offer insight to future study designs. Finally, the calculated WTA values are compared with the cost per acre estimates from the literature and survey two.

### *Buffer Strips*

Here it is important to note that the figures presented for implementing conservation buffers are not directly comparable. Reasons for this are threefold. First, the conjoint question offered an annual incentive payment per acre; it can be assumed that this is annual maintenance fees plus the establishment costs spread over the predicted life of the buffer though this assumption was not stated in the survey. Second, the type and species composition of the buffer strip was not specified in either the conjoint question or the question in survey two asking farmers to estimate their cost per acre. These variables have a significant impact on the cost of implementation. Third, the EQIP contract data allowed for a calculation of the mean cost-share amounts per practice but did not include practice-specific timelines for completion. Thus, the cost-shares and full cost estimates in Table 12 are the total incentive payments, as opposed to annual payments, made to farmers and information about the species used to establish the buffers was not available. This should all be kept in mind when comparing the respondents' WTA to implement buffer strips with other data about buffer costs per acre.

### *External Validity of WTA Results*

There are three main reasons why the calculated WTA from this analysis might vary from the actual WTA of Vermont farmers. First, the failure to include a status quo scenario in the conjoint survey question meant that there was no pre-established baseline from which to calculate farmers' CEI and WTA. This necessitated the use of the intercept as a baseline as this represents a situation in which farmers who choose not to implement any of these BMPs are paid \$4.99 per acre. This interpretation lacks external

validity and may have impacted the calculations. Second, many studies have determined that farmers would like to be paid for the ecosystem services they produce (Filson, Sethuratnam, Adekunle, & Lamba, 2009; Wossink & Swinton, 2007). It is possible that the calculated WTA results of this contingent ranking exercise elicited this desire and the total includes not only the direct costs and risk premium for implementation but a bonus payment for ecosystem services supplied. And finally, variation may have occurred because agricultural solutions are never one-size-fits-all; WTA will likely vary by farmer, main product, farm size, and farm income level and therefore this particular subset of farmers could have a WTA that varies from that of the Vermont farmer population.

#### *WTA & Other Cost per Acre Estimates*

The calculated WTA figures were not always aligned with farmers' estimated cost per acre provided on survey two or cost per acre estimates found in the literature. The reasons for this variability of estimates can be readily explained. First, farmers taking survey two were asked to provide estimates on-the-fly; the comparison would be more meaningful if farmers' could have consulted their records and provided their mean costs over the course of multiple seasons. Second, none of the literature found was specific to the Northeast and, due to differences in agricultural systems, regional research is needed to allow for accurate comparisons of implementation costs per acre.

#### **5.4.8 Program Implications**

The results of this study indicate that Vermont farmers' WTA incentive levels for these three BMPs are higher than the current cost-share amounts offered through EQIP. This lack of alignment with EQIP incentives is an issue that warrants closer

consideration. This program is the main source of financial assistance Vermont farmers have available to them to assist with BMP implementation and there is a demonstrated connection between implementing BMPs and improving environmental health; thus it is in the interest of both farmers and the government to improve the efficacy of EQIP. This mismatch between cost-share and WTA preferences may have arisen in Vermont for two reasons. First, EQIP was designed to target larger farms in other regions of the country which differ in size, geographical characteristics, and major product type when compared with Vermont farms. And second, farmers are not involved in determining incentive levels. Addressing these two issues would potentially bring EQIP incentive offers closer to farmers' WTA amounts, likely leading to an increase in the adoption rate of BMPs by Vermont farmers.

#### **5.4.9 Next Steps**

Coupling the need to simultaneously maintain the viability of agricultural systems and sustain the health of the environment in the long-term with the economic impact of incentive in BMP adoption decisions, it is important to continue this regionally-focused research to determine if the incentives offered through EQIP are sufficient to achieve those two goals. This research focuses on Vermont but it is suggested that other Northeastern states be included future research efforts; once the methods are well established, this study could then be applied to other regions of the country. Suggested avenues for future research, first relating to conjoint analysis and then means for broadening the depth of the results, are addressed below.

### *Next Steps: Conjoint Analysis*

The authors feel that the contingent ranking exercise used to determine respondents' preferences and WTA incentive levels for the three BMPs was an appropriate choice of methods. However, it would be helpful for this conjoint analysis question to be replicated in a manner that increases the likelihood of collecting a complete ranking from all respondents. Stratified sampling should be utilized to ensure representation of all farm sizes and main products. Though survey costs would increase, the authors suggest collecting conjoint data in person, perhaps by conducting a brief information session about these BMPs and then having farmers arrange flashcards containing each option in order of preference. A status quo situation should be included in the options and incentive payments offered per acre for each of the options could be adjusted based on the results of this survey. Limited but targeted demographic and motivational information should also be collected. Conducting the conjoint study in isolation, instead of as part of another survey, would decrease respondent fatigue and increase the quality of the observations.

### *Next Steps: Delving Deeper*

Results of a statewide or regional conjoint data collection effort would ideally allow for farmers to be segmented by major product, farm size, or management style to determine if farmer preferences and WTA for each conservation practice are homogenous across groups. This insight into adoption motivations and patterns would allow for more targeted outreach and education as well as inform potential adjustments to the structure and function of EQIP. However, the amount of incentive payments offered is not the

only factor which influences whether or not a farmer will engage with a conservation program and whether or not the program is cost-effective. Documenting farmers' experiences, or choices not to engage, with these programs and eliciting direct feedback on program and incentive structures is also important in shaping programs like EQIP to meet farmers' needs in each state or region.

#### **5.4.10 Conclusion**

If on-farm program effectiveness can be fully realized, more farmers could be incentivized to adopt BMPs, benefitting the long-term health and resiliency of farms, the environment, and the food system. For example, in Vermont there are 113,602 acres of cropland managed with some type of tillage (2012 Census of Agriculture). Conservation tillage is practiced on 25,452 acres and 20,120 acres are covercropped (Table 50, 2012 Census of Agriculture). If NRCS could incentivize farmers to implement conservation tillage practices on the 88,150 acres managed with conventional tillage practices by matching the WTA of farmer respondents in this survey, the estimated additional program cost would be \$7,580,019 annually. Similarly, farmers could be incentivized to covercrop the 88,150 conventionally tilled acres, under the assumption that the majority of these are left fallow, the estimated additional cost to EQIP would be \$11,032,854. Though these additional costs are significant, the benefits to agricultural systems, the environment, and society that accrue when farmers implement these BMPs are also significant. All stakeholders need to be involved in weighing the short-term costs against the benefits and determining who should pay for the benefits received to ensure the long-term sustainability and viability of our farms and food systems.



## **CHAPTER 6: ARTICLE 2**

### *The Realized Effectiveness of an Incentivized Conservation Program: Farmer perspectives on the Environmental Quality Incentives Program in Vermont*

#### **6.1 Introduction**

##### **6.1.1 Background**

The environmental degradation and negative externalities imposed on society by US agricultural production systems have been steadily increasing since the end of World War II (UNCTAD, 2013). These impacts include soil erosion, pollution of waterways and groundwater, greenhouse gas emissions, loss of biodiversity, shrinking wildlife habitat, and pesticide and fertilizer run-off and leaching (Grossman, 2011). Current trends in population growth and demand for food continue to fuel the production and impact of these externalities (UNCTAD, 2013). Climate change further compounds these challenges; rising temperatures, increasing geographic and temporal variability of precipitation, extended growing seasons, and increasing frequency of extreme weather conditions are significantly impacting agricultural systems in a multitude of ways (Walthall et al., 2013). The need to ensure the resiliency and viability of our farms and food systems is a pressing and increasingly salient issue.

The USDA and many agricultural technical service providers are currently emphasizing the need for farmers to adopt best management practices (BMPs) as an adaptation strategy to ensure the sustainable long-term use of natural resources as well as for coping with the effects of climate change (Natural Resources Conservation Service, 2012). Many demographic and farm characteristics influence farmers' decisions to adopt

BMPs but economic factors are of paramount importance (Howden et al., 2007; Wall & Smit, 2005). The practice needs to be profitable and the perceived risk associated with implementing the practice low enough in order for widespread adoption to occur (Camboni & Napier, 1993; Marra et al., 2003; Saltiel et al., 1994; Webb, 2004). However, analysis of BMP profitability is not always straightforward; the private benefits of implementation may only be tangible in the medium or long term while the costs are accrued in the short term (Bradshaw et al., 2004; Filson et al., 2009; Pannell et al., 1999; Risbey et al., 1999). In addition, implementation of BMPs creates positive externalities in the form of ecosystem services; if the costs of implementation are greater than the private benefits produced, farmers are privately funding public goods (Kroeger & Casey, 2007; Lichtenberg & Smith-Ramirez, 2011). Studies have shown that farmers feel that they should receive financial compensation for the ecosystem services produced by their farms and that farmers have a positive elastic response to reductions in the direct costs of implementing BMPs (Filson et al., 2009; Kurkalova, Kling, & Zhao, 2006; Lichtenberg, 2004).

One way in which farmers interested in implementing BMPs can receive financial assistance is through the USDA's Environmental Quality Incentives Program (EQIP). Given that farmers are navigating the cost-price squeeze while confronting the effects of climate change, this program has the potential to play an important role in simultaneously supporting the economic and environmental sustainability of farms (Natural Resources Conservation Service, 2012). However in order for EQIP to be effective at the farm-level, the program must deliver regionally appropriate programs,

specifically with regard to incentive levels and technical services (Johansson & Cattaneo, 2006; Winsten et al., 2011). Yet few studies have examined the regional effectiveness of EQIP from farmers' perspectives. This project aims to fill that gap in Vermont by documenting farmers' experiences, or choices not to engage, with EQIP and making suggestions for program improvements in the state.

### **6.1.2 Literature Review**

EQIP is a federal program administered by each state's Natural Resources Conservation Service (NRCS). The overarching goals of EQIP are to increase farmers' usage of BMPs and to assist farmers in complying with the minimum standards of environmental regulations. Incentive payments and technical assistance are available to farmers making structural improvements and implementing BMPs. Natural resource concerns, such as water quality, soil erosion, air quality, energy conservation, and preservation of biodiversity, must be directly addressed by the project in order to qualify for cost-sharing. Enrollment in the program is voluntary. Contracts may be one to ten years in duration and fund up to 75% of incurred project expenses. Payments are made to farmers upon completion of each project.

EQIP is by far the largest of the USDA's conservation programs. In fiscal year 2011, a total of 38,352 EQIP contracts were approved or completed and \$864,860,399 was obligated for conservation projects on 13,162,935 acres across the United States ([www.nrcs.usda.gov](http://www.nrcs.usda.gov)). Despite increasing levels of funding since the program began in 1996, funding gaps have become a regular occurrence in recent years which in turn affects program delivery (Eubanks, 2009). In addition, though EQIP is projected to be

minimally affected, the 2014 Farm Bill reduces aggregate spending on conservation programs by \$4 billion over the next ten years. These funding gaps and reductions, coupled with the federal government's goal of maximizing environmental benefit per dollar expended, has contributed to the trend of NRCS targeting large farms with conservation money; the economy of scale rule dictates that contracts for large farms are more efficient at reducing environmental harm and have lower administrative transaction costs per acre than those for small farms (Eubanks, 2009). Given the economic importance of agriculture in small states like Vermont, it is essential for this trend to be explored to ensure a diversity of farm types and sizes are able to access financial assistance through EQIP.

Regardless of size and geographic location, when farmers submit EQIP applications state NRCS offices evaluate, prioritize, and approve contracts using a weighted environmental index developed according to the state's environmental and resource concerns. It is important to note that the weights given to environmental priorities are assigned not by farmers but by program staff who may be influenced by the current focus of policymakers (Johansson & Cattaneo, 2006; Smith, 2006). This is significant because it has been demonstrated that the form of these environmental indices affects the function and outcomes of EQIP; the weights assigned to environmental components represent trade-offs between, and government valuation of, various components of the state's natural resource base (Johansson & Cattaneo, 2006). It follows that appropriate local indices would help ensure enrollment of farmers who are implementing practices that address the most pertinent environmental concerns in the

area (Johansson & Cattaneo, 2006). Regional policies also provide specific incentives leading to targeted results instead of approving cost-shares for practices that are more effective at solving resource concerns in other regions of the country (Smith, 2006).

After an application is approved, a contract is offered to the farmer outlining the cost-share amounts and technical assistance offered for the practices or structures the farmer wishes to implement. Economically, this is NRCS' demand curve for a certain suite of practices and, as discussed above, it varies by region according to environmental priorities. Unlike a traditional supply and demand model where the producers who are supplying the goods set the prices, in this relationship the farmers are price-takers and NRCS is both the consumer and the price-setter. Payments are designed to compensate farmers for the direct costs incurred and provide a risk premium to offset the uncertainty associated with adoption (Cooper & Signorello, 2008; Kurkalova et al., 2006). Whether or not the farmer accepts the contract offer made by NRCS is dependent on their individual willingness to accept (WTA) amount; demographic, geographic, and farm characteristics, along with the individual's degree of risk averseness, directly affect the minimum financial support a farmer requires (Claassen et al., 2008; Wossink & Swinton, 2007). It follows that in order for the program to be effective at the farm level, it is important that cost-share amounts adequately meet farmers' financial needs.

A discussion about the on-farm effectiveness of EQIP needs to go beyond the numbers and examine the outputs, outcomes, and benefits generated by implemented contracts. Both the evaluation of on-farm non-monetary benefits and contract monitoring are persistent challenges for program staff (Claassen et al., 2008). Performance measures

currently used to evaluate EQIP include the number of nutrient management plans developed and acres of cropland, grazing land, and forests managed with conservation plans ([www.nrcs.usda.gov](http://www.nrcs.usda.gov)). Quantitative environmental effect values drawn from the literature are then assigned to all components of these performance measures in USDA cost-benefit program evaluations. A more direct effort to identify and measure program outputs and outcomes was launched in 2005 when the Conservation Effects Assessment Program was established (Duriancik et al., 2008; Stubbs, 2010). However, results from this multi-organizational endeavor have been limited in scope and it remains unclear as to whether that data will establish causal linkages between implemented practices and environmental improvements at regional or farm scales (Duriancik et al., 2008). Smith (2006) suggests that the reason for these challenges is that funded projects attempt to improve many different environmental problems simultaneously; this presents practical measurement issues, leading to difficulties producing direct evidence that cost-share funds are generating the anticipated benefits. This issue is likely compounded by the fact that historically limited funding preventing adequate resources and staff time from being allocated to project monitoring. Yet, although no monitoring and evaluation contracts were funded from 1996-2008, it appears that there is a new commitment to funding this work; starting in 2012, \$482,144 has been allocated for 69 monitoring projects, 11 of which had been completed as of May 2013 (Natural Resources Conservation Service, 2013).

All of the program components discussed above frame various aspects of the ways farmers interface with EQIP. A complete examination of program effectiveness

should also objectively examine the experiences of farmers participating in the program and the impact of their participation on their businesses. A 2010 survey elicited significant differences between the viewpoints of academics, government officials, NGO employees, and farmers as to whether EQIP is effectively fostering the implementation of sustainable agricultural practices (Bailey & Merrigan, 2010). Opinions of each group varied by practice, but overall only 73% of practices funded by EQIP were judged to be advancing environmental sustainability (Bailey & Merrigan, 2010). The reasons for this discrepancy with the espoused theory of the program are not addressed by the survey authors but may be embedded in the research of others. It could be rooted in farmers, academics, government officials, and NGO employees each subscribing to a different definition of sustainability. Farmers' perceptions of program accessibility may also have been affected by the fact that both average contract size and the number of unfunded applications have increased since program inception, possibly decreasing the perceived on-farm economic sustainability of EQIP (Stubbs, 2010). Additionally, in the first five-years of the program there was a 17% farmer withdrawal rate of approved contracts and practices. This potentially indicates that the contracts NRCS staff felt were encouraging sustainability either did not parallel farmers' definition or fit their management systems (Cattaneo, 2003). To fully evaluate the effectiveness of EQIP, the shortage of research examining the program at the farm-level must be addressed.

This study aims to fill that gap by providing an examination of the effectiveness of EQIP from Vermont farmers' perspectives. Based on the literature and a previous research project, questions were developed with the goal of documenting Vermont

farmers' use of conservation practices and their experiences, or choices not to engage, with EQIP. Challenges and barriers to, as well as non-monetary benefits derived from, participation in the program are explored. Opinions about conservation program design were elicited. Results offer insight into whether EQIP effectively produces its espoused outputs and outcomes and inform suggestions for program improvements. Lastly, program areas prime for future research at the state or regional level are identified and discussed.

## **6.2 Methods**

A survey of Vermont farmers was conducted beginning in late February 2013. The instrument included structured and open-ended short answer questions designed to collect demographic data as well as information about conservation practices and conservation programs. Surveys were conducted in-person at an agricultural conference (n=11), at a farmer interest group meeting (n=6) and on-line using Lime Survey (n=44). The survey link was distributed through technical service providers' agricultural listservs and newsletters as well as through a Vermont Agency of Agriculture listserv. An incentive was offered in exchange for participation.

All Vermont farmers with a gross farm income of at least \$1000 were eligible to respond. This low threshold level was adopted to allow for representation of beginning farmers in survey responses while the distribution channels selected ensured that primarily farmers, not homesteaders or gardeners considered to have a farm under the census definition, could choose to complete this survey. The total number of responses



received was lower than anticipated by the authors (n=61). Reasons for this may include, but are not limited to, a lack of survey sponsorship or affiliation with an agricultural organization, lack of a sampling frame, or the high number of surveys Vermont farmers are asked to participate in during the winter. As a result, the authors are regarding this survey as exploratory research which serves to gather previously undocumented information and inform future projects and policies.

When analyzing the data from the structured questions, SPSS was used to calculate descriptive statistics and run crosstabs. The open-ended questions were thematically coded. New categories were developed for responses to each question until no new categories could be created. The responses that identified what farmers' EQIP contracts included were coded according to NRCS conservation practice guidelines. Frequencies of each category for each question were tallied and reported. The EQIP contract data used to compare farmers' estimated costs per acre with historical mean EQIP cost-share amounts was compiled from an NRCS contract database spanning from January 1996-May 2013 sent to the authors by an NRCS staff member. Dollar amounts were adjusted for inflation and are reported at 2013 values.

### **6.3 Results**

There were 61 respondents who completed this survey. Their demographic characteristics are summarized in Table 12. Respondents most commonly have farms between 180 and 499 acres in size, produce fluid milk as their main source of income, sell primarily in the wholesale market, and farm their land organically. Some farmers

reported other main products and market outlets; products included wool and wool products (4), maple syrup (2), fruit (2), nursery plants (1), eggs (1), and dairy heifers (1) while alternative market outlets that some farmers were using for the majority of their sales included bartering (2), on-line sales (2), and selling directly to restaurants (1). Overall, respondents' tended to rely on farm income for either a small percentage or the majority of their total household income. Approximately one-quarter of the surveys were taken on paper while the rest were completed on-line. The only significant difference between the two groups was that dairy farmers were more likely to have completed the survey on-line than on paper (.031). This is logical when the locations where paper surveys were conducted are considered.

**Table 12: Demographic Characteristics of Respondents (n=61)**

Variable	Frequency	Percent	Mean % of Income
Farm Size (Acres)			
1-9	6	9.8	-----
10-49	11	18.0	-----
50-179	14	23.0	-----
180-499	23	37.7	-----
500-999	5	8.2	-----
1000+	1	1.6	-----
Land Managed Organically (% of farms)	33	54.1	-----
Animals Managed Organically (% of farms)	17	27.9	-----

**Table 12 – continued**

Variable	Frequency	Percent	Mean % of Income
<b>Main Products Sold</b>			
(% of farms with product $\geq$ 50% of sales)			
Fluid Milk	24	39.3	90.4
Meat	13	21.3	78.1
Vegetables	7	11.5	66.43
Hay and/or crops for animal consumption	9	14.8	66.4
Other products	9	14.8	-----
<b>Market Outlets</b>			
(% of farms with market $\geq$ 50% of sales)			
Wholesale	34	55.7	83.3
Farmers' markets or farmstand	18	29.5	77.4
CSA	9	14.8	76.7
Other market	6	9.8	-----
<b>Mean Household Income from Farm (%)</b>			
0-24	21	34.4	-----
25-49	7	11.5	-----
50-74	8	13.1	-----
75-99	15	24.6	-----
100	9	14.8	-----

Respondents were then compared with the population of farmers in Vermont (see Table 13). For this survey, dairy farmers, organic farmers, and farmers with 180-499 acres are overrepresented while farmers managing 10-179 acres are underrepresented.

**Table 13: Comparison of Survey Respondents with Vermont Farmer Population**

Variable	Survey Respondents		Vermont Farmers	
	Frequency	Percent	Frequency	Percent
<b>Farm Size (acres)</b>				
1-9	6	9.8	616	8.4
10-49	11	18.0	2258	30.8
50-179	14	23.0	2414	32.9
180-499	23	37.7	1513	20.6
500-999	5	8.2	383	5.2
1000+	1	1.6	154	2.1
<b>Products Sold</b>				
(% of farms with product $\geq$ 50% of sales)				
Fluid Milk	34	55.7	934	12.7
Meat	18	29.5	-----	-----
Vegetables	9	14.8	814	11.1
Hay and/or crops for animals	6	9.8	3396	46.3
Land certified organic (%)	33	54.1	513	7.0

All respondents were asked to provide information about the barriers, if any, that they face when implementing conservation practices and their preferences for certain conservation program structures (Table 14). Half of the respondents indicated that cost was the biggest challenge when implementing conservation practices on their farms. Finding the time to implement practices was the second most frequently cited challenge. With regards to program structure, that of EQIP was most often preferred by respondents (36.1%). However it is important to note that 24.6% of respondents felt they lacked enough information to accurately differentiate between program structures and 16.4% indicated they did not have a preference.

**Table 14: Respondent opinions about conservation practices and programs**

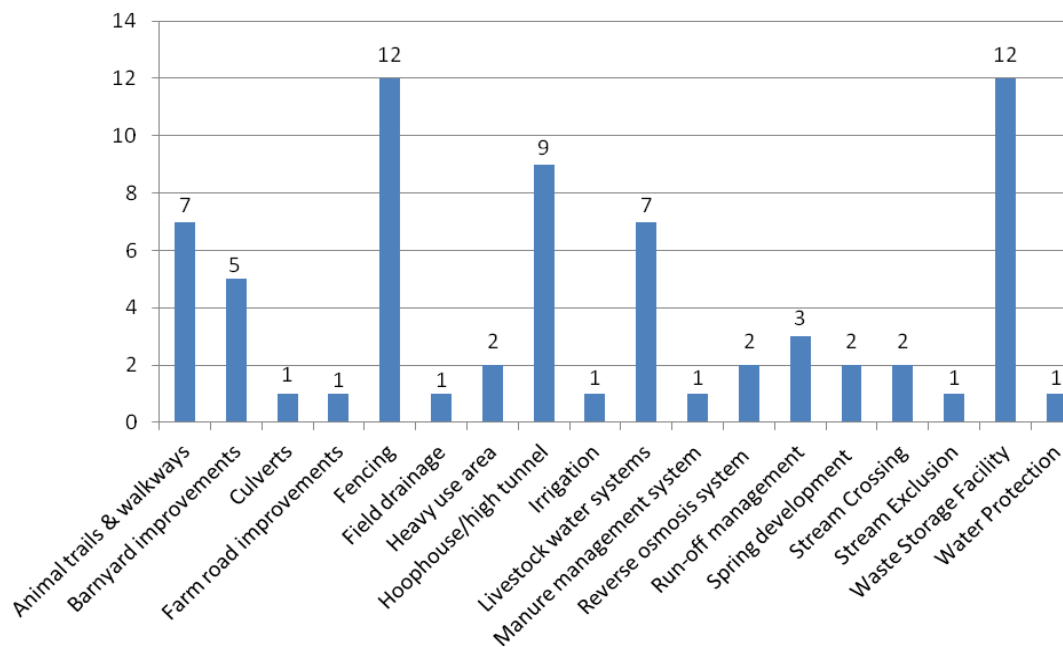
	Frequency	Percent
<b>Biggest BMP Implementation Challenge</b>		
Cost	31	50.8
Time	12	19.7
Integrating practice into existing system	5	8.2
Lack of information	2	3.3
Other	2	3.3
No challenges faced	3	4.9
I have not implemented any BMPs	5	8.2
<b>Preferred Program Structure</b>		
VT Farm Agronomic Practice Program	12	19.7
EQIP	22	36.1
CSP	2	3.3
I do not have a preference	10	16.4
I need more information to decide	15	24.6
<b>Program Participation</b>		
Applied for EQIP	41	67.2
Had/Have EQIP Contract	37	60.7

Farmers were then asked to indicate whether they had applied for and received an EQIP contract (Table 14). The majority (67.2%) of respondents had applied and all but four had then enrolled in the program. The total participation rate in EQIP among survey respondents was 60.7%. No significant demographic differences existed between respondents who had participated in EQIP and those who had not. Farmers growing hay and other crops for animal feed had the highest rate of participation in EQIP while meat producers had the lowest and value-added producers did not engage with the program at all (Table 15). The average number of practices per contract was 2.6 though respondents' contracts included a range of one to eight contracts. The mean and the range of the number of practices per contract was largest for meat and dairy farmers while vegetable, hay, and farmers growing other crops tended to contract for one to four practices (Table 15).

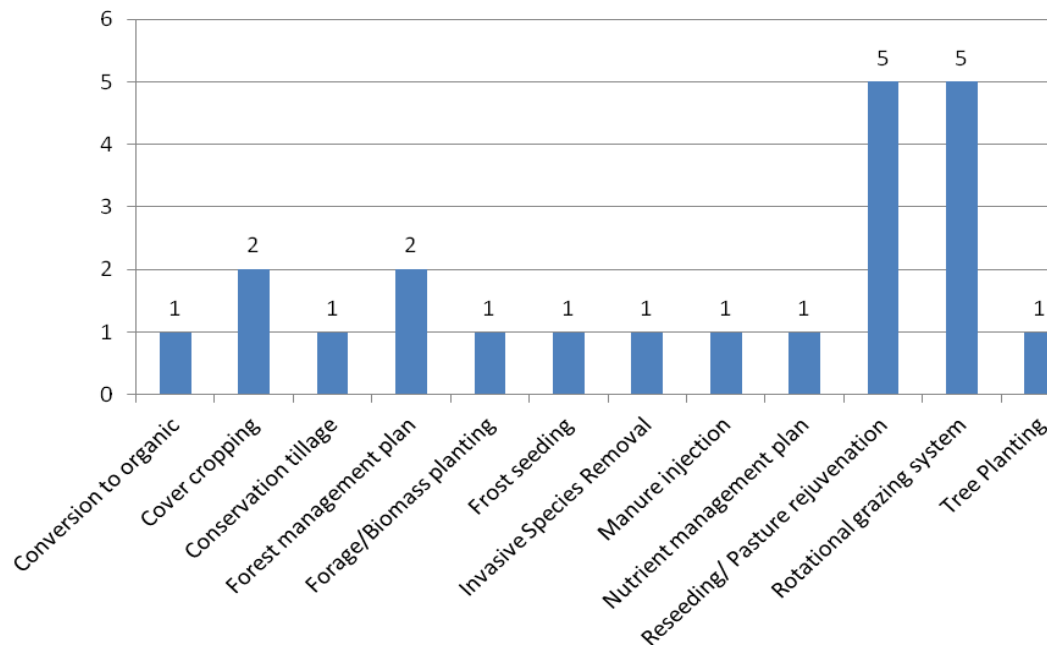
The practices and the frequency with which each practice was included in respondents' contracts are depicted in Figures 3 and 4. Respondents' contracts included structural improvements more frequently than BMPs. The structural improvements most often cost-shared were waste storage facilities and fencing while the most commonly funded management practices were pasture rejuvenation and rotational grazing systems. These structures and practices are most commonly used by dairy and meat farmers.

**Table 15: EQIP Participation Statistics by Main Product**

Main Product	% of Farmers with EQIP Contract	Mean Number of Practices/Contract	# of Practices: Range
Hay & Other Crops (n=9)	66.7%	1.8	1-4
Fluid Milk (n=24)	62.5%	3.1	1-8
Vegetables (n=7)	57.1%	1.3	1-2
Other Products (n=9)	55.6%	2.0	1-3
Meat (n=13)	53.8%	3.1	1-6

**Figure 3: Frequencies of Structural Improvements in Respondents' EQIP Contracts**





**Figure 4: Frequencies of Management Practices in Respondents' EQIP Contracts**

Respondents tended to have completed their contract or were actively enrolled in the program and were continuing to maintain their infrastructure and implement their management practices (Table 16). Only one respondent had canceled their contract at the time of this survey. All but three farmers were fully maintaining their infrastructure and all but four were continuing to fully implement their management practices after their contract had ended. Respondents generally felt that the amount of money in their contracts was either sufficient (51.4%) or lower than they felt was appropriate (32.4%).

**Table 16: Summary of Respondents' Experiences with EQIP Contracts**

Variable	Frequency	Percent
Completed Contract	27	73.0
Contract in Process	9	24.3
Continued to Maintain Infrastructure	24	64.9
Contract for Infrastructure still Active	10	27.0
Continued to Implement BMPs	18	48.6
Contract for BMPs still Active	9	24.3
Contract did not include BMPs	6	16.2
Amount of Money in Contract Was:		
A little more than needed	4	10.8
Just right	19	51.4
Low	7	18.9
Not nearly enough	5	13.5
Received Non-monetary Benefits	17	45.9
Encountered Challenges	16	43.2
Fixed Original Resource Concern		
Fully	19	51.4
Partially	5	13.5
Not at all	6	16.2
Contract is still active	4	10.8
Created New Resource Concern	5	13.5

Applications for EQIP contracts need to directly address a resource concern in order to be considered for funding. Approximately half of the respondents had fully remedied their targeted resource concern with the practices in their contracts. However, 29.7% had not fixed or only partially fixed their concerns and 13.5% had created new resource concerns as they implemented their contract. The new resource concerns cited included: contracts not addressing all the issues on the farm and an inability to procure additional funding to address the problem (3), new cattle lanes built in some locations highlighting the need for lanes in all areas (1), and management issues created by planting cover crops too late (1).

Short open-ended response questions in the survey asked respondents who had or have an EQIP contract to identify the challenges they had when considering and enrolling in the program as well as the non-monetary benefits they have received as a result of implementing their contracts. Table 17 below presents these benefits and challenges and the frequency with which each was identified by respondents. The most frequently encountered challenges with EQIP were the ability to get applications ranked high enough to be approved and encountering unanticipated or hidden costs as practices were being implemented. Included in this hidden cost category were items farmers considered necessary for contract implementation, such as irrigation for a funded hoophouse, which were not allocated cost-share funds in their contracts. The benefit most often received by respondents was the development of a supportive relationship with their local NRCS staff members from which they received helpful information about the program and conservation practice implementation. When conservation practices

were implemented, farmers tended to see on-farm improvements which benefitted their management and production systems.

**Table 17: Frequency of Non-monetary Benefits & Challenges Received by Respondents**

Benefit	Frequency
Beneficial and supportive relationship with NRCS staff	5
Expanded knowledge/educational information	4
Improved nutrient/manure management	4
Improved farm production systems	3
Improved pastures and paddocks	2
Technical assistance	2
Climate control on high value crops	1
Healthier animals	1
Higher milk quality payments	1
More efficient energy use	1
More pollinators & wildlife	1
Challenge	Frequency
Contract/project ranking system (to get it funded)	5
Hidden costs	5
Too much paperwork	3
Availability of information	2
Hard for beginning/non-landowning farmers to access	2
Timing of reimbursements	2

**Table 17 - continued**

Challenge	Frequency
Working/communicating with NRCS staff	2
Incompatibility of system with "real life challenges" dealt with by farmers	1
Limited implementation time	1
Overengineering of project	1

The 24 survey respondents who had never enrolled in EQIP identified the reasons why they had chosen not to engage with the program in three short open-ended questions. Six respondents had actually applied to EQIP but were not offered a contract. Three respondents did not have resource concerns that ranked high enough on the environmental priority index to be funded, two cited the small size of their farm as having prevented them from receiving funding, and one had submitted an application after the annually allocated funds had been distributed. Four farms had applied to EQIP, were offered a contract, and turned it down. Farm size again influenced this decision as the payment amount per acre on these small farms led two farmers to conclude the contract was not worthwhile. Overengineering of a project made the total cost of a project too high for another farmer and the fourth did not like the final contract requirements.

The remaining 14 survey respondents who had never engaged with EQIP had never submitted an application to the program. Reasons for this decision and the frequency of each reason are presented in Table 18 below. Stringent ranking and contract approval standards as well as a lack of knowledge about EQIP were the most frequently

cited reasons that respondents chose not to apply. It should be noted that most of these barriers were also identified as challenges to participating in the program.

**Table 18: Frequency of Reasons Respondents had Never Applied to EQIP**

Reason	Frequency
Lack of program knowledge/information	5
Strict requirements of practice/ranking	5
Opportunity cost of paperwork, meetings, etc.	4
Rather do it independently (of government)	4
Lack of formal/long-term land lease	3
Not creating many resource concerns	2
Incompatibility of practices/structures with existing farm system/business	1
Lack of funds to pay farm's portion of cost-share	1
Overengineering of structures	1
Small farm size	1

Respondents' estimated cost per acre for BMP implementation was then compared with the mean EQIP incentive payments per acre and the number of times the practice was funded or canceled since program inception in 1996 (Table 19). Results are separated by EQIP program year and all dollar figures have been adjusted to 2013 levels. Since 1996, the mean EQIP cost-share per acre for cover cropping has more than doubled

and the number of times the practice has been contracted has increased tenfold. If it is assumed that the mean cost-share payment accounts for 75% of total costs, farmers' estimated cost per acre is approximately equal to the extrapolated average total expense budget for the practice. Incentive payments for conservation tillage incentive payments peaked during EQIP 2002 and are now at a level that exceeds the survey respondents' total estimated expense budget. The number of adopters of conservation tillage has been steadily increasing as the number of canceled tillage contracts decreases. The numbers for conservation buffers do not allow for a straightforward cost comparison due to the many possible types of buffers and the fact that the survey question did not clarify if buffer costs provided should be a lump sum for establishment or if establishment costs should be averaged and added to annual maintenance costs; EQIP contracts granted account for all expenses combined over the length of the contract. It is notable however that though conservation buffers are allocated the most capital, this practice also has the highest rate of cancelation.

**Table 19: Historical EQIP Incentive Payments**

Practice	Program	Mean Cost Share \$/Acre*	Mean Full Cost \$/Acre	Farmers' 2013 Estimated Cost/Acre	# of Times Practice Funded & Implemented	# Times Practice Canceled or Deleted
Cover Cropping	EQIP 1996	20.49	-----	-----	23	10
	EQIP 2002	25.90	-----	-----	100	33
	EQIP 2008	57.13	76.17	77.26	197	32

**Table 19 – continued**

Practice	Program	Mean Cost Share \$/Acre*	Mean Full Cost \$/Acre	Farmers' 2013 Estimated Cost/Acre	# of Times Practice Funded & Implemented	# Times Practice Canceled or Deleted
Conservation Tillage	EQIP 1996	18.60	-----	-----	6	10
	EQIP 2002	75.83	-----	-----	14	15
	EQIP 2008	47.85	63.80	46.94	33	2
Conservation Buffers				95.00		
Contour Buffer Strips	EQIP 2008	289.98	386.64	-----	1	0
Field Border	EQIP 1996	0	-----	-----	2	11
	EQIP 2002	3326.11	-----	-----	19	8
	EQIP 2008	765.96	1021.28	-----	7	1
Filter Strip	EQIP 1996	1799.58	-----	-----	37	64
	EQIP 2002	925.41	-----	-----	71	52
	EQIP 2008	666.64	888.84	-----	12	0

\* Adjusted to 2013 dollars



## **6.4 Discussion**

The results of this exploratory survey highlight five program areas which should be addressed in-depth. Each is discussed separately below followed by a section identifying program areas recommended to be targeted if the effectiveness of EQIP is to be improved. This is followed by a brief “need to know” list generated for farmers thinking about participating in EQIP. And finally, this discussion section will conclude by identifying areas of future research which the authors believe could further program improvement efforts.

### **6.4.1 Cost-Share Amounts**

Cost was identified as the biggest challenge of conservation practice implementation by half of survey respondents, which further supports the conclusion in the literature that economic variables tend to be the determining factor in adoption decisions. Additionally, the opportunity cost of the time required to implement new practices translates into a direct impact on the economic bottom line of the farm. In examining farmers’ opinions of cost-share amounts it is important to remember that the traditional supply and demand model does not apply in this situation. Instead, NRCS both demands and sets the prices for conservation practice implementation, so though farmers are the suppliers they are price-takers. Of the farmers who responded to this survey, 32.4% felt that they received insufficient financial support from NRCS for their contracted practices and structures.

When cost-share amounts are compared to respondents’ estimated implementation expenses, for these specific BMPs the cost-share payments are roughly equivalent to 75%

of estimated costs per acre. It is important to note, however, that the estimates in Table 6 are from a very small sample size. Potential reasons for this situational alignment are fivefold. First, these BMPs account for a small percentage of funded contract practices and so may not be the particular practices for which farmers feel the cost-share is insufficient. Second, it is possible that farmers if are not tracking their actual costs of implementation, that they are basing their cost-share opinions on incorrect estimates. Third, EQIP incentive payments do not vary based on farm size but incurred costs per acre do vary accordingly. Based on the mean farm size in Vermont, this fact may mean that the current cost-share system is not working well for many small farms in the state. It is also possible that farmers are only examining the short-term expenses accrued and not factoring in the long-term benefits they have received as a result of implementation. Many non-monetary benefits were identified by farmers that improve management and production systems, thus further offsetting the short-term costs and improving the bottom line in the medium and long-term. And lastly, the hidden costs that many farmers have encountered as they implemented their contracts can drive up out-of-pocket expenses for items that arguably should have been included in the initial contract.

#### **6.4.2 Application Ranking & Contract Approval**

It has been demonstrated that the form of the environmental indices used in the application process directly impacts the outcomes of the approval and enrollment process of conservation programs like EQIP (Johansson & Cattaneo, 2006). Appropriate indices, developed regionally, help NRCS staff target financial assistance towards farmers who wish to implement practices that are effectively addressing the most pertinent

environmental concerns in the area (Johansson & Cattaneo, 2006; Smith, 2006). However, the ranking system used to determine which projects and practices receive funding was frequently cited by respondents as being both a challenge and a barrier to engaging with EQIP. Most commonly, farmers found that having a small farm, on which NRCS will likely not maximize the environmental benefit generated per dollar spent on the contract, and being “too good” of a farmer decreased their chances at getting approved for a contract. While it can be argued that farmers whose activities are environmentally sustainable should not be prioritized over those who are actively polluting, many farmers do feel they should be paid for producing ecosystem services and a rewards-based system of financial support would likely further increase supply and benefit Vermont’s agricultural economy and environmental health (Filson et al., 2009). The contradictory nature of this situation, where NRCS tailors environmental indices regionally but farmers feeling that those indices are creating a barrier to enrollment, needs to be addressed in order to increase the realized effectiveness of EQIP at the farm-level.

#### **6.4.3 Resource Concerns & Sustainability**

The question has been raised in the literature as to whether or not EQIP is effectively promoting the adoption of practices that increase the long-term sustainability of agricultural systems (Duriancik et al., 2008). One indicator of sustainability is the degree to which the resource concerns the contract is designed to address are being resolved. The results of this survey indicate that roughly one-third of respondents implemented practices which did not fully remedy their resource concerns. Further

compounding this issue, when contracted practices highlighted other resource concerns or generated new ones, additional funding was not provided to address those issues. If EQIP contracts are not offsetting short-term costs incurred by promoting sustainability and generating non-monetary systemic benefits in the medium and long-term, farmers may be considerably less motivated to participate in the program.

#### **6.4.4 Structural Improvements vs. Management Practices**

In this group of farmers, structural improvement projects were more frequently funded than management practices. EQIP contract data demonstrates that this is the case for the population of farmers in Vermont as well (Natural Resources Conservation Service, 2013). One reason for this trend may be that implementing structural improvement projects on large farms, for example by creating a waste management system in a barnyard, is the most efficient way to maximize the environmental benefit generated per dollar spent. However, given the potential of BMPs adoption to increase the adaptive capacity of farms and to help ensure the sustainable use of natural resources in our food system, there is clearly a need to continue encouraging BMP adoption in Vermont (Walthall et al., 2013). To do so effectively may require an examination of the EQIP contract policy which prevents repeated funding for the same practice; to support continued implementation of BMPs after the end of the initial contract would increase non-monetary benefits received and ecosystem services supplied by farmers, thereby promoting long-term sustainability of agricultural systems. Continued funding for maintenance of a structural improvement seems less of a priority; if it can be assumed that funded structures are inextricably integrated in the farm system more thoroughly than

a management practice, it can be concluded that funds would be most effective if committed to continuation of management practices before infrastructure maintenance.

#### **6.4.5 Understanding Program Structure**

The incentive structure of EQIP was preferred by survey respondents over that of the CSP and Vermont's Farm Agronomic Practice Program. A few factors that may have influenced respondents' opinions warrant closer examination. The first is simply that EQIP is the major source of financial and technical assistance available to farmers in Vermont and thus it is also the program most familiar to farmers in the state. The CSP is a reward-based incentive program that is not widely utilized in Vermont because the payments per acre are not typically enough to make enrollment worthwhile for small farms. Vermont's Farm Agronomic Practice Program does not involve contracts and allows for repeated annual funding of implemented conservation practices. However it is a state program with a limited pool of funds targeted for a limited number of conservation practices. In addition, about 25% of respondents did not have enough baseline knowledge of the program structures to differentiate between the three options presented. Lack of sufficient information about EQIP was cited as both a barrier and a challenge to participation in the program. Prioritizing the diffusion of information would likely help to increase EQIP enrollment and subsequently to increase the adoption rate of BMPs. Prioritizing transparency in this information sharing would help to avoid hidden costs as well as surprises about contract details and the amount of time required for paperwork, thus reducing farmers' frustration with the way the program functions while decreasing the number of canceled practices and contracts.

#### **6.4.6 Summary of Program Areas to Target**

- Contract ranking process
- Contract development
  - Incentive levels offered
  - Elimination of “hidden project costs” that are not included in contracts
  - Timeline for reimbursing farmers for project expenses
- Outcome monitoring
- Education and outreach
  - Ensure that EQIP is accessible to farm of all sizes and types
- Qualifying current BMPs for EQIP funding
  - Determine whether a rewards-based program would be more effective

#### **6.4.7 Farmers “Need to Know” EQIP List**

The following points are what the author considers the most important points farmers should consider when deciding whether or not to engage with EQIP. The list presents the four highlight points; it is not intended to be a comprehensive guide for farmers.

- It is possible that the current characteristics of your farm (i.e. size, main product) may lead you to the conclusion that EQIP is not compatible with your management system and production goals.
- Before applying to EQIP, researching the expected cost per acre of BMP implementation and calculating your individual WTA amount will prove helpful

in determining what practices to include in your application and whether to accept your contract offer.

- The opportunity cost of applying to the program may be high but it tends to be outweighed by the non-monetary benefits you will accrue in the long-term.
- Additional funding may be available for you to add project outcome monitoring to your contract. Doing so may generate valuable information that may improve your farm system and that of many other Vermont farms.

#### **6.4.8 Next Steps**

The results of this exploratory survey suggest areas to target for future research endeavors and program evaluations. It is the hope of the authors that projects such as this can improve the farm-level realized effectiveness of EQIP in Northeastern states. There are four specific areas to be prioritized in future efforts. First, it should be investigated as to whether the challenges and non-monetary benefits experienced by the respondent group are experienced by a representative sample of farmers in Vermont and in the other Northeastern states. This could serve to bring validity to the hypothesis that incentives and program structure should be adapted to fit each region of the country. Second, these surveys of Northeastern farmers should be complemented by surveys of NRCS staff in each state in order to determine whether NRCS staff have different visions of what program effectiveness entails and to increase the transparency of program operations. Third, regional cost-benefit analyses and outcome monitoring could be undertaken with the intent of reducing program implementation, technical assistance, and project costs with the underlying goal of allocating more money to fund contracts. Though the lack of

widespread project outcome monitoring was not raised by this group of farmers as a challenge of participation, focus in Vermont has recently shifted to the need for monitoring systems. Data collected could aid in directing funds towards the practices that have the most potential for environmental and resiliency improvements at local levels. Finally, it would be valuable to determine where farmers are getting their information about EQIP and other conservation programs. If farmers who are choosing not to enroll are doing so only after talking to farmers who have had challenging experiences with NRCS, then the alignment of challenges and barriers to participation elicited in this study loses a great deal of validity. By mapping farmers' communication networks, accurate information could be disseminated in a more timely fashion, perhaps coupled with information on the benefits of adopting BMPs.

#### **6.4.9 Conclusion**

This research clearly demonstrates that there are many program areas that could be targeted with further evaluation and improvements in order to improve the realized on-farm effectiveness of EQIP. Though changing a federal program can be a daunting task, it is the hope that by documenting farmers' experiences, and choices not to engage, with EQIP, the regional need for programmatic change can be realized and achieved. The end result of these efforts will not only promote the dual goals of improving environmental health and agricultural production systems but address the pressing need of ensuring the long-term sustainability and viability of our farms and food systems.



## WORKS CITED

- Adger, W. N., Agrawala, S., Mirza, M. M. Q., Conde, C., O'Brian, K., Pulhin, J., ...  
Takahashi, K. (2007). *Assessment of adaptation practices, options, constraints, and capacity* (pp. 717–743). Cambridge, UK: Cambridge University Press. Retrieved from <http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter17.pdf>
- Alriksson, S., & Öberg, T. (2008). Conjoint analysis for environmental evaluation: A review of methods and applications. *Environmental Science and Pollution Research*, 15(3), 244–257. doi:10.1065/espr2008.02.479
- Bailey, M. R., & Merrigan, K. A. (2010). Rating sustainability: An opinion survey of national conservation practices funded through the Environmental Quality Incentives Program. *Journal of Soil and Water Conservation*, 65(1), 21A–25A. doi:10.2489/jswc.65.1.21A
- Blamey, R. K., Bennett, J. W., Louviere, J. J., Morrison, M. D., & Rolfe, J. C. (2002). Attribute causality in environmental choice modeling. *Environmental and Resource Economics*, 23(2), 167–186.
- Brown, L. A. (1981). *Innovation diffusion: a new perspective*. London ; New York: Methuen.
- Bryant, Christopher R., Smit, Barry, Brklacich, Michael, Johnston, Thomas R., Smithers, John, Chiotti, Quentin, & Singh, Bhawan. (2000). Adaptation in Canadian Agriculture to Climatic Variability and Change. *Climatic Change*, 45, 181–201.
- Camboni, S. M., & Napier, T. L. (1993). Factors affecting use of conservation farming practices in East Central Ohio. *Agriculture, Ecosystems & Environment*, 45(1), 79–94.

- Carolan, M. S. (2005). Barriers to the Adoption of Sustainable Agriculture on Rented Land: An Examination of Contesting Social Fields. *Rural Sociology*, 70(3), 387–413.  
doi:10.1526/0036011054831233
- Carolan, M. S. (2012). *The sociology of food and agriculture*. London; New York: Routledge.
- Cary, J. W., & Wilkinson, R. L. (1997). Perceived profitability and farmers' conservation behaviour. *Journal of Agricultural Economics*, 48(1-3), 13–21.
- Cattaneo, A. (2003). The pursuit of efficiency and its unintended consequences: Contract withdrawals in the Environmental Quality Incentives Program. *Review of Agricultural Economics*, 25(2), 449–469.
- Cattin, P., & Wittink, D. R. (1982). Commercial Use of Conjoint Analysis: A Survey. *Journal of Marketing*, 46(3), 44–53.
- Claassen, R., Cattaneo, A., & Johansson, R. (2008). Cost-effective design of agri-environmental payment programs: U.S. experience in theory and practice. *Ecological Economics*, 65(4), 737–752. doi:10.1016/j.ecolecon.2007.07.032
- Cooper, J. C., & Signorello, G. (2008). Farmer premiums for the voluntary adoption of conservation plans. *Journal of Environmental Planning and Management*, 51(1), 1–14.
- Darby, H. (2012, November 9). Cost of Conservation Practices in Vermont.
- Ding, Y., Schoengold, K., & Tadesse, T. (2009). The Impact of weather extremes on agricultural production methods: does drought increase adoption of conservation tillage practices? *Journal of Agricultural and Resource Economics*, 34(3), 395–411.
- Duriancik, L. F., Bucks, D., Dobrowolski, J. P., Drewes, T., Eckles, S. D., Jolley, L., ... Weltz, M. A. (2008). The first five years of the Conservation Effects Assessment Project.

*Journal of Soil and Water Conservation*, 63(6), 185A–197A.

doi:10.2489/jswc.63.6.185A

Eubanks, W. (2009). A Rotten System: Subsidizing Environmental Degradation and Poor Public Health with Our Nation's Tax Dollars. *Stanford Environmental Law Journal*, 28, 213.

Feder, G., & Umali, D. L. (1993). The adoption of agricultural innovations: a review.

*Technological Forecasting and Social Change*, 43(3), 215–239.

Frye, W. W., & Blevins, R. L. (1989). Economically sustainable crop production with legume cover crops and conservation tillage. *Journal of Soil and Water Conservation*, 44(1), 57–60.

Garrod, G. D., & Willis, K. G. (1997). The non-use benefits of enhancing forest biodiversity: a contingent ranking study. *Ecological Economics*, 21(1), 45–61.

Green, P. E., Krieger, A. M., & Wind, Y. (2001). Thirty Years of Conjoint Analysis: Reflections and Prospects. *Interfaces*, 31(3\_supplement), S56–S73.

doi:10.1287/inte.31.3s.56.9676

Green, P. E., & Srinivasan, V. (1978). Conjoint analysis in consumer research: issues and outlook. *Journal of Consumer Research*, 103–123.

Green, P. E., & Srinivasan, V. (1990). Conjoint Analysis in Marketing: New developments with implications for research and practice. *Journal of Marketing*, 54(4), 3–19.

Grossman, M. R. (2011). Good Agricultural Practice in the United States: Conservation and Climate. *Environmental Law Review*, 13(4), 296–317.

- Grubinger, V. (2012). *Promoting Zone Tillage among Commercial Vegetable Growers in Vermont* (pp. 1–13). University of Vermont Extension. Retrieved from [http://www.uvm.edu/vtvegandberry/Pubs/Final\\_Report\\_CIG\\_Zone\\_Till.pdf](http://www.uvm.edu/vtvegandberry/Pubs/Final_Report_CIG_Zone_Till.pdf)
- Halbrendt, C., Pesek, J., Parsons, A., & Lindner, R. (1995). Using Conjoint Analysis to Assess Consumers' Acceptance of pST-supplemented Pork. In *Valuing Food Safety and Nutrition* (pp. 129–153). Boulder, CO: Westview Press.
- Hanley, N., Mourato, S., & Wright, R. E. (2001). Choice Modeling Approaches: A Superior Alternative for Environmental Valuation? *Journal of Economic Surveys*, 15(3), 435–462.
- Hartwig, N. L., & Ammon, H. U. (2002). Cover crops and living mulches. *Weed Science*, 50(6), 688–699.
- Horne, P. (2006). Forest owners' acceptance of incentive based policy instruments in forest biodiversity conservation-A choice experiment based approach. *Silva Fennica*, 40(1), 169.
- Howden, S. M., Soussana, J.-F., Tubiello, F. N., Chhetri, N., Dunlop, M., & Meinke, H. (2007). Adapting agriculture to climate change. *Proceedings of the National Academy of Sciences*, 104(50), 19691–19696. doi:10.1073/pnas.0701890104
- Idowu, J., Rangarajan, A., van Es, H., & Schindelbeck, B. (n.d.). *Fact Sheet #1: Zone Tillage*. Cornell University. Retrieved from [http://www.vegetables.cornell.edu/reducedtillage/ZTFactSheet\\_1.pdf](http://www.vegetables.cornell.edu/reducedtillage/ZTFactSheet_1.pdf)
- IPCC. (2008). *IPCC Fourth Assessment Report*.

- Johansson, R. C., & Cattaneo, A. (2006). Indices for Working Land Conservation: Form Affects Function. *Applied Economic Perspectives and Policy*, 28(4), 567–584.  
doi:10.1111/j.1467-9353.2006.00323.x
- Khanna, M. (2001). Non-mandatory approaches to environmental protection. *Journal of Economic Surveys*, 15(3), 291–324.
- Knowler, D., & Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: A review and synthesis of recent research. *Food Policy*, 32(1), 25–48.  
doi:10.1016/j.foodpol.2006.01.003
- Kroeger, T., & Casey, F. (2007). An assessment of market-based approaches to providing ecosystem services on agricultural lands. *Ecological Economics*, 64(2), 321–332.  
doi:10.1016/j.ecolecon.2007.07.021
- Kurkalova, L., Kling, C., & Zhao, J. (2006). Green subsidies in agriculture: Estimating the adoption costs of conservation tillage from observed behavior. *Canadian Journal of Agricultural Economics/Revue Canadienne D'agroeconomie*, 54(2), 247–267.
- Lichtenberg, E. (2004). Cost-responsiveness of conservation practice adoption: A revealed preference approach. *Journal of Agricultural and Resource Economics*, 29(3), 420–435.
- Lichtenberg, E., & Smith-Ramirez, R. (2011). Slippage in Conservation Cost Sharing. *American Journal of Agricultural Economics*, 93(1), 113–129. doi:10.1093/ajae/aaq124
- Louviere, J. L. (1988). Conjoint Analysis Modeling of Stated Preferences: A review of theory, methods, recent developments, and external validity. *Journal of Transport Economics and Policy*, 22(1), 93–118.

- Lovell, S. T., & Sullivan, W. C. (2006). Environmental benefits of conservation buffers in the United States: Evidence, promise, and open questions. *Agriculture, Ecosystems & Environment*, 112(4), 249–260. doi:10.1016/j.agee.2005.08.002
- Lowrance, R., Dabney, S., & Schultz, R. (2002). Improving water and soil quality with conservation buffers. *Journal of Soil and Water Conservation*, 57(2), 36A–43A.
- Marra, M., Pannell, D. J., & Ghadim, A. A. (2003). The economics of risk, uncertainty and learning in the adoption of new agricultural technologies: where are we on the learning curve? *Agricultural Systems*, 75(2), 215–234.
- Mendelsohn, R. (2000). Efficient adaptation to climate change. *Climatic Change*, 45(3), 583–600.
- Metz, B. (2007). *Climate Change 2007-Mitigation of Climate Change: Working Group III Contribution to the Fourth Assessment Report of the IPCC* (Vol. 4). Cambridge University Press.
- Natural Resources Conservation Service. (2009). Environmental Quality Incentives Program: Programmatic Environmental Assessment. Retrieved from [http://www.nrcs.usda.gov/Internet/FSE\\_DOCUMENTS/nrcs143\\_006910.pdf](http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_006910.pdf)
- Natural Resources Conservation Service. (2013). Conservation Program Contract Data Set.
- Osteen, C., Gottlieb, J., & Vasavada, U. (2012). Agricultural Resources and Environmental Indicators, 2012 edition. *US Department of Agriculture, Economic Research Service. Economic Information Bulletin*, (98). Retrieved from <http://ers.usda.gov/media/874175/eib98.pdf>
- Pannell, D. (1999). Social and economic challenges in the development of complex farming systems. *Agroforestry Systems*, 45(1), 395–411. doi:10.1023/A:1006282614791

- Payson, S. (1994). *Quality Measurement in Economics: New perspectives on the evolution of goods and services*. Brookfield, VT: Elgar.
- Prokopy, L. S., Floress, K., Klotthor-Weinkauff, D., & Baumgart-Getz, A. (2008). Determinants of agricultural best management practice adoption: Evidence from the literature. *Journal of Soil and Water Conservation*, 63(5), 300–311.  
doi:10.2489/jswc.63.5.300
- Qiu, Z. (2003). A VSA-Based Strategy for Placing Conservation Buffers in Agricultural Watersheds. *Environmental Management*, 32(3), 299–311. doi:10.1007/s00267-003-2910-0
- Rangarajan, A. (2011). *Reducing Tillage in Vegetable Systems: Progress to Date*. Cornell University. Retrieved from  
<http://www.hort.cornell.edu/expo/proceedings/2011/Reduced%20Tillage/Rangarajan%20Expo%20Summary%202011.pdf>
- Risbey, J., Kandlikar, M., Dowlatabadi, H., & Graetz, D. (1999). Scale, context, and decision making in agricultural adaptation to climate variability and change. *Mitigation and Adaptation Strategies for Global Change*, 4(2), 137–165. doi:10.1023/A:1009636607038
- Rodale Institute. (2011). *Cover Crops And No-Till Management for Organic Systems.pdf* (No. 20636). Retrieved from  
<http://www.sare.org/content/download/65453/919599/file/Cover%20Crops%20And%20No-Till%20Management%20for%20Organic%20Systems.pdf?inlinedownload=1>
- Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New York: Free Press.

- Ryan, R. L., Erickson, D. L., & De Young, R. (2003). Farmers' Motivations for Adopting Conservation Practices along Riparian Zones in a Mid-western Agricultural Watershed. *Journal of Environmental Planning and Management*, 46(1), 19–37.  
doi:10.1080/713676702
- Saltiel, J., Bauder, J. W., & Palakovich, S. (1994). Adoption of Sustainable Agricultural Practices: Diffusion, Farm Structure, and Profitability. *Rural Sociology*, 59(2), 333–349.  
doi:10.1111/j.1549-0831.1994.tb00536.x
- SARE. (2007). *Managing Cover Crops Profitably, 3rd Edition / Books / Learning Center / SARE Nationwide - SARE* (3rd ed.). SARE Outreach. Retrieved from <http://www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition>
- Sarrantonio, M., & Gallandt, E. (2003). The Role of Cover Crops in North American Cropping Systems. *Journal of Crop Production*, 8(1-2), 53–74. doi:10.1300/J144v08n01\_04
- Schultz, R., Collettil, J., Isenhardt, T., Simpkins, W., Mize, C., & Thompson, M. (1995). Design and placement of a multi-species riparian buffer strip system. *Agroforestry Systems*, 29(3), 201–226. doi:10.1007/BF00704869
- Smit, B., & Skinner, M. W. (2002). Adaptation options in agriculture to climate change: a typology. *Mitigation and Adaptation Strategies for Global Change*, 7(1), 85–114.  
doi:10.1023/A:1015862228270
- Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, 16(3), 282–292.



- Smit, Barry, Burton, Ian, Klein, Richard J.T., & Wandel, J. (2000). An anatomy of adaptation to climate change and variability. *Climatic Change*, 45, 223–251.
- Smith, K. R. (2006). Public payments for environmental services from agriculture: precedents and possibilities. *American Journal of Agricultural Economics*, 88(5), 1167–1173.
- Snapp, S. S., Swinton, S. M., Labarta, R., Mutch, D., Black, J. R., Leep, R., ... O'Neil, K. (2005). Evaluating cover crops for benefits, costs and performance within cropping system niches. *Agronomy Journal*, 97(1), 322–332.
- Soil and Water Conservation Society and Environmental Defense. (2007). *Environmental Quality Incentives Program Assessment* (Program Assessment). Retrieved from [http://www.swcs.org/documents/filelibrary/EQIP\\_assessment.pdf](http://www.swcs.org/documents/filelibrary/EQIP_assessment.pdf)
- Stock, P. V. (2007). “Good Farmers” as Reflexive Producers: an Examination of Family Organic Farmers in the US Midwest. *Sociologia Ruralis*, 47(2), 83–102.  
doi:10.1111/j.1467-9523.2007.00429.x
- Stubbs, M. (2010). Environmental Quality Incentives Program (EQIP): Status and Issues. In *Congressional Research Service, Report for Congress R* (Vol. 40197). Retrieved from <http://www.whprp.org/NLE/CRSreports/10Apr/R40197.pdf>
- Swinton, S. M., Lupi, F., Robertson, G. P., & Hamilton, S. K. (2007). Ecosystem services and agriculture: Cultivating agricultural ecosystems for diverse benefits. *Ecological Economics*, 64(2), 245–252. doi:10.1016/j.ecolecon.2007.09.020
- Tate, K. W., Atwill, E. R., Bartolome, J. W., & Nader, G. (2006). Significant Attenuation by Vegetative Buffers on Annual Grasslands. *Journal of Environment Quality*, 35(3), 795.  
doi:10.2134/jeq2005.0141

- Tourte, L., Buchanan, M., Klonsky, K., & Mountjoy, D. (2003). *Estimated Costs and Potential Benefits for an Annually Planted Cover Crop* (pp. 1–5). University of California Cooperative Extension. Retrieved from [http://coststudies.ucdavis.edu/conservation\\_practices/files/12747.pdf](http://coststudies.ucdavis.edu/conservation_practices/files/12747.pdf)
- Tufekcioglu, A., Raich, J. W., Isenhardt, T. M., & Schultz, R. C. (2003). Biomass, carbon and nitrogen dynamics of multi-species riparian buffers within an agricultural watershed in Iowa, USA. *Agroforestry Systems*, 57(3), 187–198. doi:10.1023/A:1024898615284
- Uri, N. D. (2000). An evaluation of the economic benefits and costs of conservation tillage. *Environmental Geology*, 39(3), 238–248. doi:10.1007/s002540050004
- USDA. (2013). *The Budget for Fiscal Year 2013* (pp. 65–70). Washington, D.C. Retrieved from [https://bb.uvm.edu/bbcswebdav/pid-1037418-dt-content-rid-3334787\\_1/courses/201301-13976/USDAbudget2013.pdf](https://bb.uvm.edu/bbcswebdav/pid-1037418-dt-content-rid-3334787_1/courses/201301-13976/USDAbudget2013.pdf)
- Valentin, L., Bernardo, D. J., & Kastens, T. L. (2004). Testing the Empirical Relationship between Best Management Practice Adoption and Farm Profitability. *Applied Economic Perspectives and Policy*, 26(4), 489–504. doi:10.1111/j.1467-9353.2004.00195.x
- Van der Meulen, H. A. B., De Snoo, G. R., & Wossink, G. A. A. (1996). Farmers' perception of unsprayed crop edges in the Netherlands. *Journal of Environmental Management*, 47(3), 241–255.
- Wall, E., & Smit, B. (2005). Climate Change Adaptation in Light of Sustainable Agriculture. *Journal of Sustainable Agriculture*, 27(1), 113–123. doi:10.1300/J064v27n01\_07
- Walthall, C. L., Hatfield, J., Backlund, P., Lengnick, L., & Marshall, E. (2013). *Climate Change and Agriculture in the United States: Effects and Adaptation* (USDA Technical

- Bulletin No. 1935) (p. 186 pages). Washington, D.C: USDA. Retrieved from [http://www.usda.gov/oce/climate\\_change/effects\\_2012/CC%20and%20Agriculture%20Report%20\(02-04-2013\)b.pdf](http://www.usda.gov/oce/climate_change/effects_2012/CC%20and%20Agriculture%20Report%20(02-04-2013)b.pdf)
- Webb, T. (2004). Understanding behaviour: Social and economic influences on land practice change. *Land Management Practices Information, Priorities, Classification and Mapping—towards an Agreed National Approach*. Kamberra Winery, Canberra, 11–12.
- Winsten, J. R., Baffaut, C., Britt, J., Borisova, T., Ingels, C., & Brown, S. (2011). Performance-based incentives for agricultural pollution control: identifying and assessing performance measures in the United States. *Water Policy*, 13, 677–692.
- Wittink, D. R., & Cattin, P. (1989). Commercial use of conjoint analysis: an update. *The Journal of Marketing*, 91–96.
- Wossink, A., & Swinton, S. M. (2007). Jointness in production and farmers' willingness to supply non-marketed ecosystem services. *Ecological Economics*, 64(2), 297–304. doi:10.1016/j.ecolecon.2007.07.003
- Wyland, L. J., Jackson, L. E., Chaney, W. E., Klonsky, K., Koike, S. T., & Kimple, B. (1996). Winter cover crops in a vegetable cropping system: Impacts on nitrate leaching, soil water, crop yield, pests and management costs. *Agriculture, Ecosystems & Environment*, 59(1–2), 1–17. doi:10.1016/0167-8809(96)01048-1
- Yano, Y., & Blandford, D. (2009). Use of Compliance Rewards in Agri-environmental Schemes. *Journal of Agricultural Economics*, 60(3), 530–545. doi:10.1111/j.1477-9552.2009.00208.x